AD 665302

RDTR No. 105
January 1968

VOLUME II OF II

25 MILLION CANDLE CAST FLARE, DIAMETER AND BINDER STUDY

(Summary Report June 66 to June 67)

BERNARD E. DOUDA
U. S. Naval Ammunition Depot
Crane, Indiana 47522

Prepared under MIPR PG-6-58 for the Illumination Branch, Targets and Scorers Division, Air Force Armament Laboratory, Eglin Air Force Base, Florida

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This report was reviewed for adequacy and technical accuracy by Mr. W. S. Cronk, Mr. Larry Moran, and Captain Gene Holder, Eglin Air Force Base and Mr. Clarence Gilliam, NAD Crane.

Submitted by:

B. H. CALKINS, Director
Research and Development Department

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ABSTRACT

The feasibility of making an illuminating candle which produces a luminous intensity of 25 million candles is demonstrated. The goal is achieved by igniting all surfaces of a star shaped cavity which is formed through the center of the candle. Two horzontally opposed flames are generated by this candle.

The relationship between candle diameter and the ability of that candle to generate light efficiently is reported. This study includes data for both pressed and cast candles and shows the effect of different binder types. A general degradation of efficiency is observed as the cast candle diameter increases from 4 inches to 24 inches. The pressed candle series shows a maximum near the 4 inch diameter with degradation to either side.

Silicone, epoxy-polyglycol, polyester, polysulfide, and various combinations of these binders are described as they are used to make candles for the diameter study and the 25 million candle flare. A study of flare compositions consisting of magnesium and sodium perchlorate, the latter being partially dissolved in various methacrylate monomers is reported. A limited environmental program for a 4.5 inch diameter candle cast in an aluminum candle case and the development of a liner system for that candle is described. A polyester-epoxy

binder is used successfully to make a cast candle whose luminous efficiency is comparable to a candle made by the conventional pressed method.

Flame orientation and flame size effects are described. Contrary to common opinion, it is shown that a small flame size rather than a large flame from a given candle diameter is associated with candles which produce light with high efficiency. The binder is shown to be a major factor in the generation of various flame sizes and thus strongly influences the candle efficiency.

INTRODUCTION

This exploratory development program was conducted between June 1966 and June 1967 for the Air Force Armament Laboratory, Eglin Air Force Base, Florida, under MIPR-PG-6-58. The main objectives of the program were twofold. One goal was to demonstrate the feasibility of making an illuminating candle which has a luminous intensity of 25 million candles. This is a five-fold increase over the intensity delivered by the BRITEYE candle. The second goal was to conduct a study of the relationships between the diameter of a candle and the efficiency of light production from that candle. Both goals were attained during the contract period.

To assist the reader, the report is divided into four parts. Part I deals with the 25 million candle flare, Part II with the diameter studies, Part III with binder studies, and Part IV with flame orientation and flame size effects. Although the report is divided for convenience, it is noteworthy that all phases of this work are interrelated; that is, information generated in any one part is also utilized in the other phases in

an effort to extract the maximum amount of data from a minimum amount of work and hardware expenditure. With these remarks, the reader is encouraged to view this work as an integrated program instead of four distinct tasks.

The report is bound in two volumes. The main body of the report is in Volume I. The Appendices are in Volume II. A Table of Contents, Abstract, and Introduction for the entire report has been inserted at the beginning of each volume for convenience.

APPENDIX I

FLARE FABRICATION PROCESS

Magnesium and sodium nitrate have been used extensively for making illuminating flare compositions. Their granular size is often varied to cause changes in the burning rate of the composition. Also, the ratio of these ingredients causes changes in the burning rate as well as the efficiency (cd-sec/g). A third ingredient is normally added to the system. That ingredient, the binder, is normally a plastic in monomeric form which later can be polymerized to bond the composition to itself and to its container. In compositions prepared for casting, the binder content normally ranges from 9 - 15% by weight.

Generally, in preparing the composition, the binder and magnesium are preblended in a mixer. This preblending process desensitizes the magnesium, reduces the dust hazard, and inhibits surface oxidation of the magnesium particles. The sodium nitrate is later added to the preblend. This mass is then mixed until a homogeneous blend is obtained. When the binder content is about 12%, the composition has physical properties analogous to freshly ground hamburger. The material doesn't flow nor seek its own level. It can be molded, formed, and packed under mild pressure.

The general procedure for making a candle consists of tamping the composition in place under pressure of about 50 - 60 psi. The star cavity is formed by means of a mold which is later removed. After polymerization of the binder system, the composition is

rigid and strong. The composition must also adhere in some manner to the flare container. This is necessary to prevent premature burning in the composition-case interface. A good bond between these two surfaces can be achieved by various techniques. One technique is to bond the composition directly to the case. Another is to introduce a liner between the case and the composition. That liner is bonded to both the case and the composition. The case bond must usually be able to withstand severe changes of temperature such as -65°F to +160°F and be sufficiently strong to withstand the normal safety and durability tests. Accordingly, the bond system must be developed in conjunction with the candle hardware.

APPENDIX II

STAR CONFIGURATION COMPUTATIONS

by Ralph Chipman

The configuration of an internal burning cavity was investigated. The problem was to determine the configuration of a star shaped cavity put in the center of a 16 inch flare that would produce a constant burning as the flare burned internally from the center outward. Since the burning surface is the product of the length of the flare and the perimeter of the cross section of the burning area, the problem reduces to obtaining a configuration that produces a constant cavity perimeter during burning. Equations to compute the perimeter were developed assuming the burning rate perpendicular to the burning surface was constant in all directions. Using these equations, a computer program was written to compute perimeter versus linear displacement of the burning surface for various shaped stars. Since five inches of linear burning was desired, the diameter of the star was fixed at six inches.

Although the goal of constant perimeter was not achieved, the best results came from a six-pointed star with the dimensions shown in Figure 1. Figure 2 shows a cross section of the theoretical burning surface at various burning distances for this configuration and a graph of the perimeter versus diameter is shown in Figure 3. As can be seen from the graph, the perimeter is nearly constant for the first two inches of burning and then

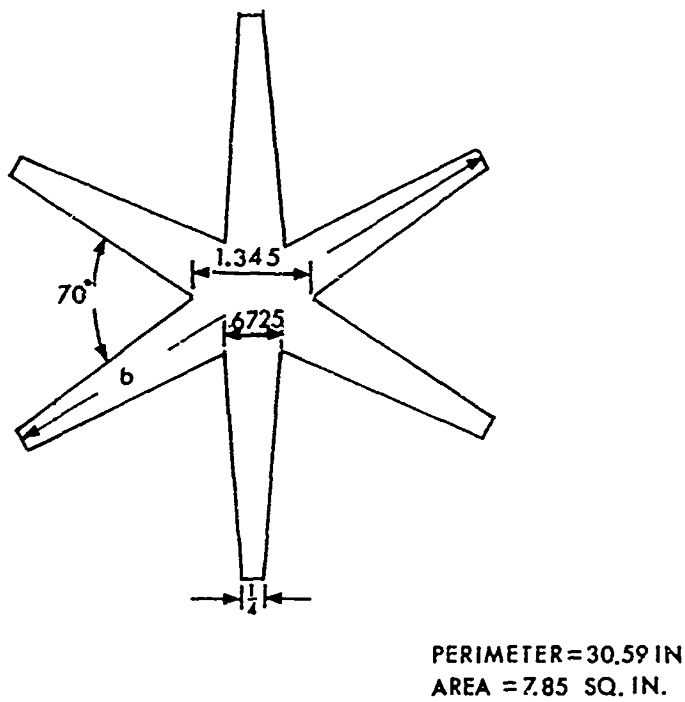


Figure 1-Cross Section of Configuration Which Gave Best Results

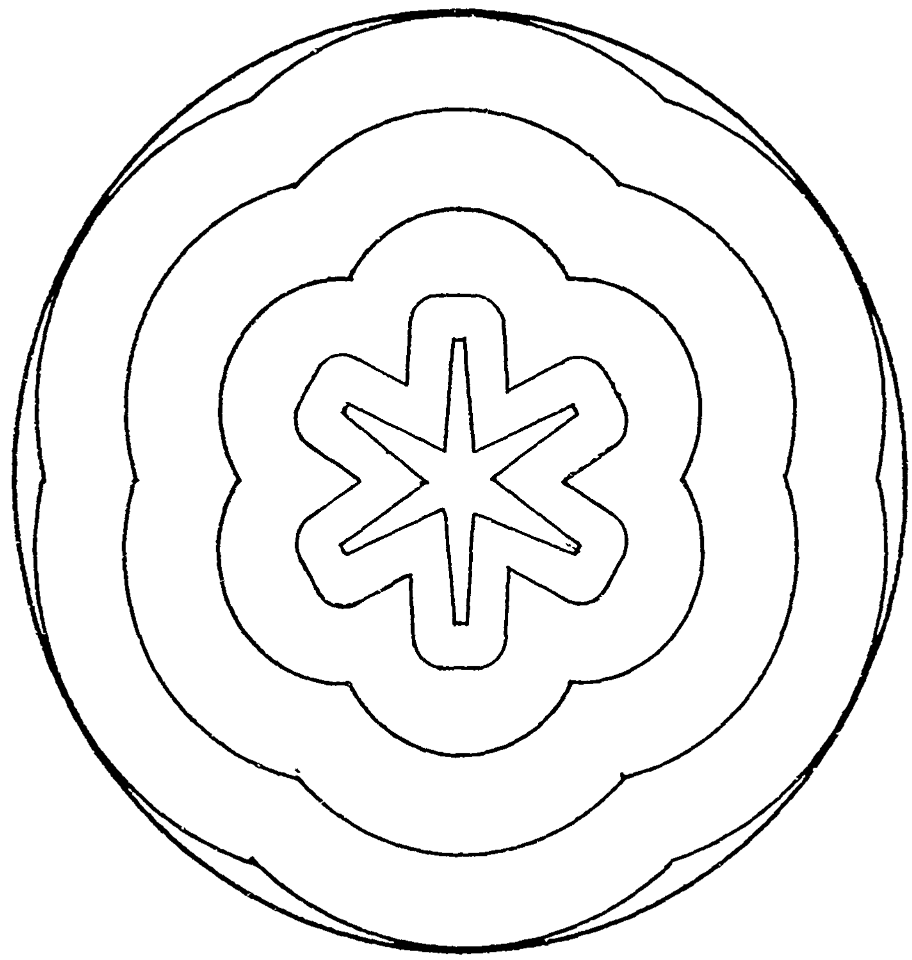


Figure 2-Cross Section of Theoretical Burning Surface at Various Burning Distances for Best Configuration.

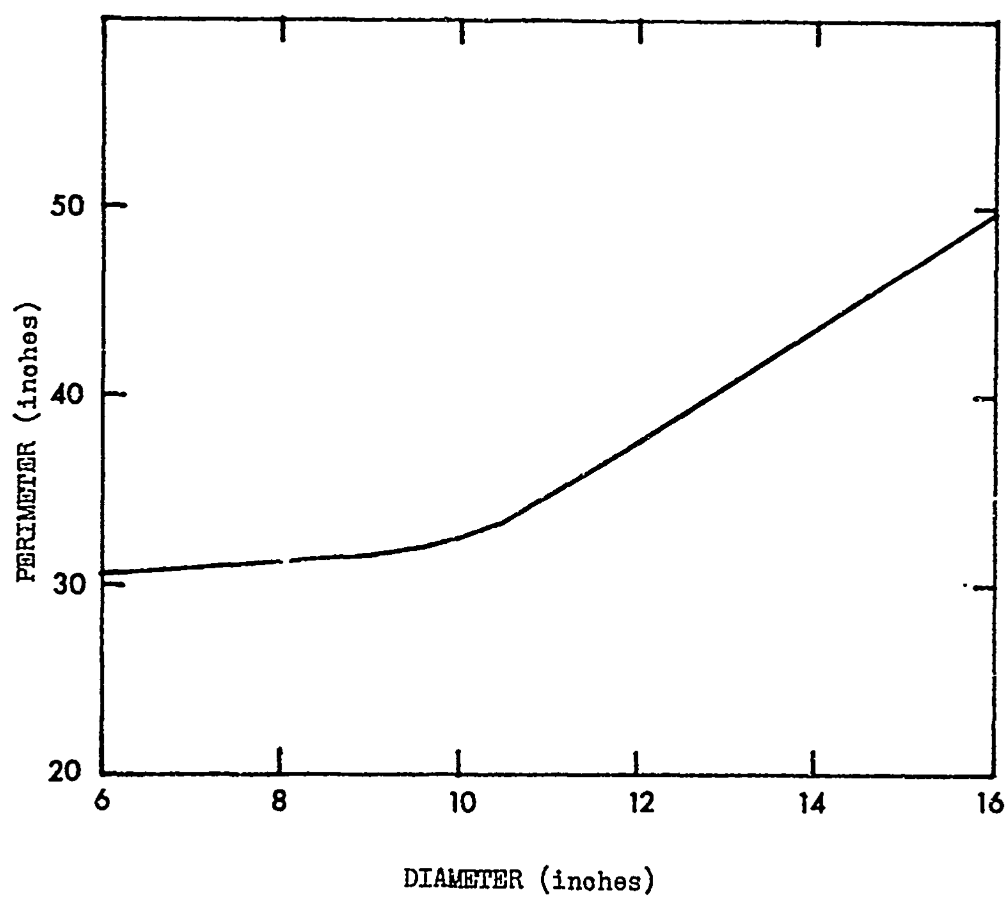


Figure 3-Perimeter Versus Diameter of Cross Section of Best Configuration.

approaches a straight line with a positive slope. The slope of this line, which is the graph one would obtain if the star shaped cavity were replaced by a cylindrical hole, is equal to pi.

Other shaped stars that were tried include various shaped four-, five-, and eight-pointed stars and six-pointed star with other combinations of star point widths and sizes of angle between the sides of the points. In all of the other cases of four-, five-, and six-pointed stars, the graph of perimeter versus diameter came closer to the line representing the case of the cylindrical hole. For the eight-pointed star, the perimeter first decreased to a minimum and then increased. The graph of a typical case of a few of these combinations are shown in Figure 4.

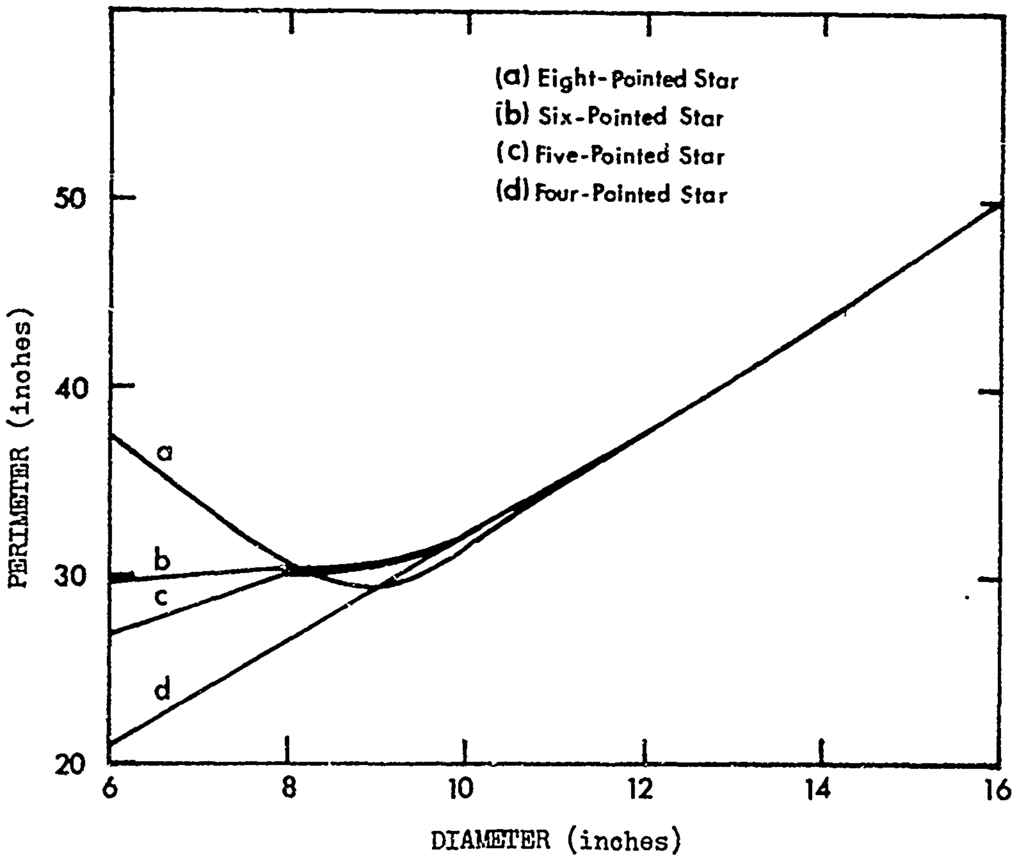


Figure 4-Perimeter Versus Diameter of Cross Section of Various Configurations.

Mathematical Derivation of Perimeter Equations

The following is the derivation of the equations for the perimeter of a burning star cavity assuming the burning rate perpendicular to the burning surface is constant in all directions. The final equations of the derivation are listed on page 151 of "Solid Propellant Rockets".[1] However, there is an error in the equation for initial perimeter given there.

Let N equal the number of star points. The star is then completely defined by the radius, R, and the angles A, B, and C. See Figure 5. The value of C is found by the expression

$$C = \frac{2\pi}{N}$$

and B is determined by the width of the end of the star points. A is free to vary over a range of values. The initial perimeter, P_o, is equal to (see Figure 5)

$$P_o = 2N\,(a+X). \qquad (1)$$

The value of a is given by

$$a = R\,(C-B). \qquad (2)$$

From the law of sines we have

$$\frac{X}{\sin B} = \frac{R}{\sin(\pi-A)}$$

By substituting $\sin A = \sin(\pi-A)$, we get

$$\frac{X}{\sin B} = \frac{R}{\sin A}$$

and solving for X we obtain

$$X = \frac{R \sin B}{\sin A}\,. \qquad (3)$$

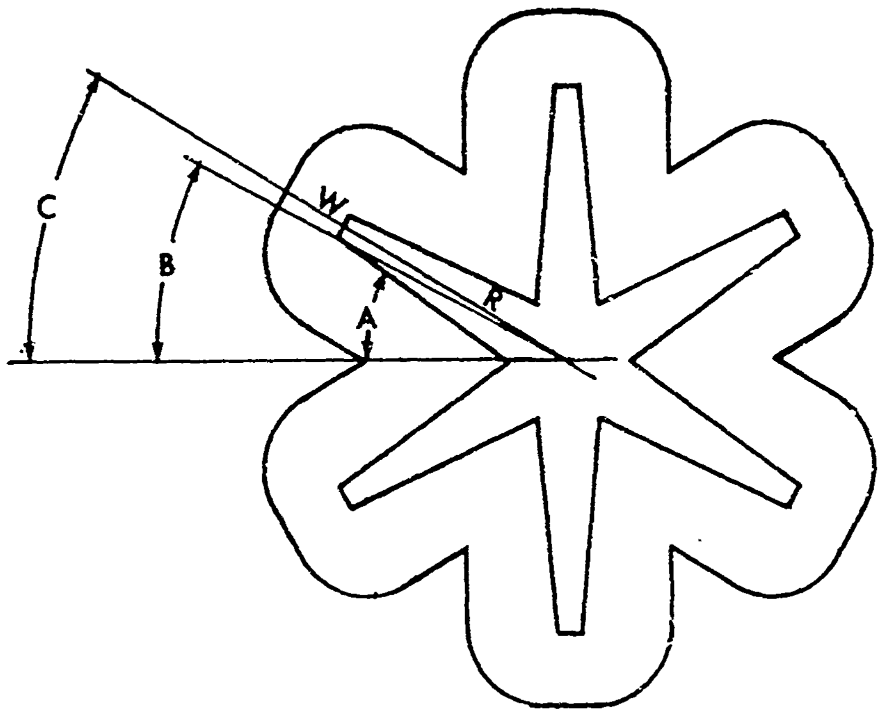


Figure 5A-Dimensions Used in Caloulations of Perimeter

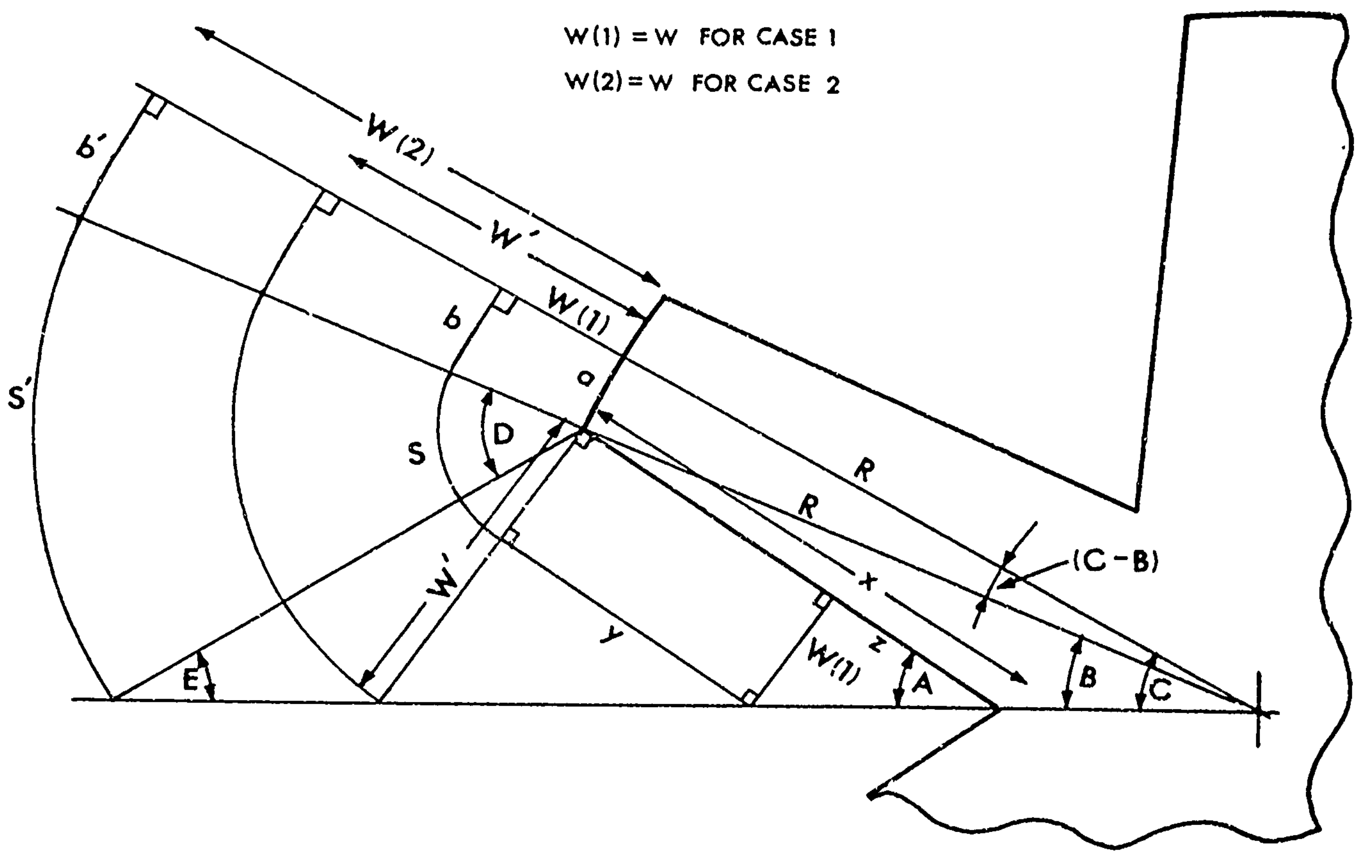


Figure 5B-Perimeter of One-half of a Star Point Before and After Straight Sides Disappear

by substituting Eq (2) and Eq (3) in Eq (1) we get

$$P_o = 2NR\left(C-B+ \frac{\sin B}{\sin A}\right) \tag{4}$$

Let W equal the linear displacement of the burning surface from its original position. To find the perimeter during burning, two cases must be considered. One case is the period that the straight sides of the star points exist and the other is the period after the straight sides disappear. Let W' be the value of W at the point where the straight sides of the star points first disappear.

$$W' = X \tan A = R \frac{\sin B}{\sin A} \tan A = R \frac{\sin B}{\cos A}$$

<u>Case 1</u>

$W < \frac{R \sin B}{\cos A}$, straight sides of star points exist.

From Figure 5 we see that for this case the perimeter is

$$P = 2N(b + s + y). \tag{5}$$

The value of b is

$$b = (R+W)\ (C-B) = R(C-B) + W(C-B) \tag{6}$$

and $$s = W\ (\pi/2 - A + B). \tag{7}$$

Since $y = X - Z$ and $Z = W \cot A$

We have by substitution

$$y = R \frac{\sin B}{\sin A} - W \cot A. \tag{8}$$

By substituting Eq. 6, 7, and 8 in Eq. 5 and simplifying we obtain

$$P = 2NR\ (C-B + \frac{\sin B}{\sin A}) + 2NW\ (\pi/2 + C - A - \cot A)$$

or $$P = P_o + 2NW\ (\pi/2 + C - A - \cot A) \tag{9}$$

Case 2

$W > \frac{R \sin B}{\cos A}$, after straight sides of star points disappear.

The perimeter for the second case in Figure 5 is

$$P = 2N\,(b' + s') \qquad (10)$$

where the value of b' is

$$b' = (R+W)\,(C-B) = R(C-B) + W(C-B). \qquad (11)$$

From the law of sines we have

$$\frac{R}{\sin E} = \frac{W}{\sin B}$$

therefore

$$\sin E = \frac{R \sin B}{W}$$

and

$$E = \sin^{-1} \frac{R \sin B}{W} .$$

Since $s' = WD$ and $D = B+E$

we have

$$s' = W\left(B + \sin^{-1} \frac{R \sin B}{W}\right) \qquad (12)$$

By substituting Eq. 11 and Eq. 12 in Eq. 10 and simplifying, we get

$$P = 2N\left[R\,(C-B) + W\left(C+\sin^{-1} \frac{R \sin B}{W}\right)\right] \qquad (13)$$

Equations 4, 9 and 13 are the necessary equations for finding the perimeter in all cases.

Reference

(1) Huggett, Bartley and Mills, "Solid Propellant Rockets", Princeton University Press, Princeton, New Jersey, 1960.

APPENDIX III

COMPUTER PRINTOUT OF TEST DATA

This appendix contains the computer printout of the test data for MAPI flares 300, 342, 343, 394, 426, 427, 463. 464, and 556.

For each of the test flares, the printout presents the data in both numerical and graphical forms. In the numerical printouts various values are tabulated against instantaneous time during the burning period. The second column is the average luminous intensity of the high 29 photocells. The third column is the integrated candle-seconds from time zero. The fourth column is the running mean luminous intensity in units of candles taken from time zero. The fifth column is the running mean luminous intensity taken from time ten seconds. The sixth column is the standard deviation of the high 29 photocells and the seventh column is a uniformity factor which is defined as the high 29 average photocell reading minus the low 29 average photocell reading divided by the average photocell reading of all cells where the average is equal to the high average plus the low average divided by two. Thus, the uniformity factor can range from zero to 2.0 and is a measure of the uniformity of the light distributed in a spherical pattern. For example, when the light is perfectly distributed, the uniformity factor is zero. Thus, the closer this number is to zero the more uniform is the light distribution.

One graph shows the photocell intensity data plotted as a function of time. In that graphical presentation the photocells

are not sorted. Each photocell is plotted against time to show the variation of intensity on that photocell. These plots frequently overlap because the cell may be high at one instant in time whereas it may be low at another instant in time depending upon smoke conditions and other factors. In contrast to this, another graphical presentation is presented wherein the photocell data is sorted and plotted against time. In that presentation, the uppermost plot, for example, is the plot of the highest reading vs. time regardless of which cell is sensing this value. The second highest plot is a graph of the second highest reading vs. time regardless of which cell is sensing that value, etc. In this presentation, the plots do not overlap.

Another graph is presented which is a plot of intensity against time of the high 29, the low 29, and the average of all 58 cells. Since more than 56 cells are never used and often times less than 56 cells are used, the average of the low 29 is biased in the low direction by the number of cells which are not in use. The cells not in use are read by the computer as having an intensity of zero. On the other hand, the high 29 which are selected by the computer are representative of the intensity of the unit in the direction which is the most free from smoke and other light interferences. The plot of the average candlepower of all of the photocells is also biased in the low direction depending once again upon the number of cells that are not in use.

Another graph is presented which shows the integral candle-seconds against time. The linearity of this plot is a measure of the constancy of light output.

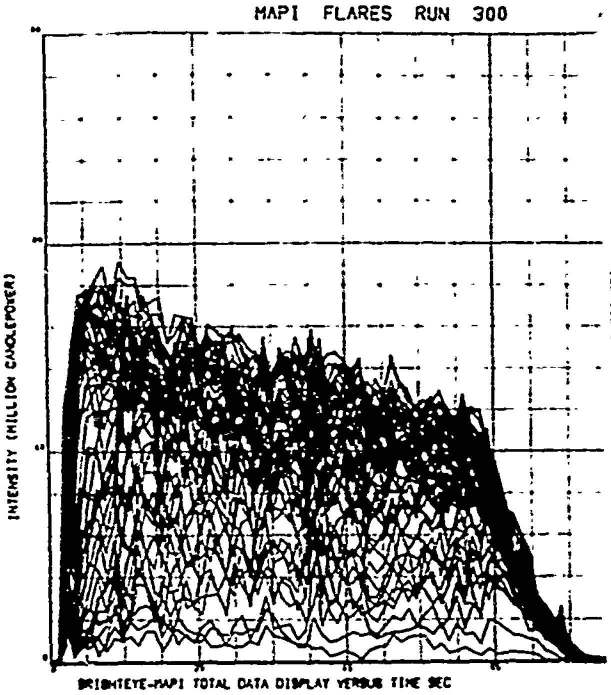
Another presentation is a plot of average luminous intensity against time starting with instantaneous time zero and time ten seconds. Graphical presentations are also included to show the standard deviation of the luminous intensity of the high 29 and low 29 photocells and to show the uniformity factor versus time.

NAPI FLARES RUN 309

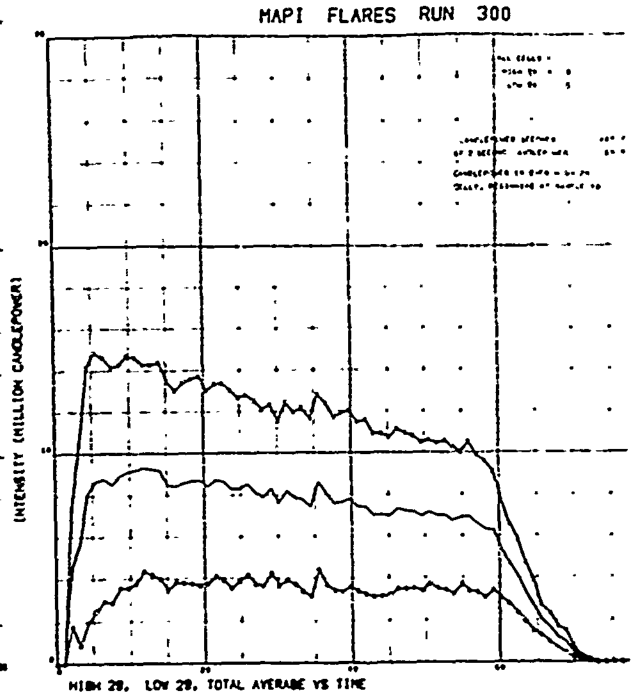
INSTANTANEOUS TIME, AVERAGE OF HIGH 29 PHOTOCELLS, INTEGRATED CANDLEPOWER SECONDS FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME 10, STANDARD DEVIATION OF HIGH 29 PHOTOCELLS,UNIFORMITY FACTOR

TIME (SEC)	HIGH 29 AVG	CP-SEC	AVG CP 0 SEC	AVG CP 10 SEC	STD DEV	U
0.	0.	0.	0.	0.	0.	0.
1.08	0.	3.97	1.84	0.	0.	0.
2.16	7.36	13.57	4.20	0.	2.25	1.23
3.23	10.48	28.85	6.25	0.	3.35	1.70
4.31	14.19	42.50	7.89	0.	2.98	1.52
5.39	14.20	58.39	9.05	0.	2.51	1.42
6.46	14.62	73.88	9.72	0.	2.34	1.35
7.54	14.15	89.14	10.35	0.	2.57	1.33
8.62	14.27	104.71	10.80	0.	2.08	1.20
9.69	14.66	120.49	11.19	0.	1.95	1.22
10.77	14.64	136.06	11.49	14.48	2.03	1.18
11.84	14.27	151.45	11.72	14.37	1.80	1.07
12.92	14.29	166.89	11.92	14.36	1.42	1.10
14.00	14.38	181.89	12.07	14.25	1.58	1.13
15.08	13.47	196.15	12.14	14.05	1.91	1.18
16.15	13.01	210.37	12.21	13.91	1.29	1.08
17.23	13.38	224.89	12.28	13.84	1.44	1.12
18.31	13.57	239.58	12.38	13.82	1.89	1.13
19.39	13.69	253.97	12.41	13.77	1.85	1.16
20.46	13.04	268.16	12.45	13.71	1.27	1.11
21.54	13.34	282.52	12.49	13.68	1.84	1.06
22.61	13.36	296.73	12.53	13.64	1.53	1.09
23.69	13.04	310.58	12.54	13.58	1.72	1.15
24.77	12.87	324.31	12.55	13.52	1.60	1.06
25.85	12.81	337.95	12.55	13.46	1.46	1.02
26.92	12.52	351.19	12.54	13.39	1.38	1.08
28.00	12.09	364.32	12.53	13.32	1.55	1.08
29.08	12.31	377.18	12.51	13.24	1.71	0.98
30.15	11.54	390.10	12.49	13.17	1.30	1.04
31.23	12.43	403.26	12.48	13.13	1.85	1.04
32.31	11.98	416.27	12.47	13.08	1.64	1.05
33.39	12.16	429.11	12.45	13.02	1.83	1.15
34.47	11.65	442.28	12.44	12.99	1.67	1.15
35.54	12.80	455.85	12.45	12.97	1.57	0.97
36.62	12.39	468.83	12.44	12.94	1.73	1.09
37.70	11.72	481.55	12.42	12.89	1.42	1.09
38.77	11.91	494.42	12.41	12.86	1.62	1.12
39.85	12.04	507.07	12.39	12.82	1.41	1.08
40.92	11.48	519.48	12.37	12.77	1.55	1.09
42.00	11.58	531.59	12.34	12.72	1.68	1.12
43.08	10.93	543.34	12.31	12.67	1.18	1.11
44.15	10.91	555.00	12.27	12.61	1.10	1.11
45.23	10.78	566.77	12.24	12.56	1.31	1.08
46.30	11.14	578.63	12.21	12.51	1.45	1.04
47.38	10.95	590.33	12.18	12.47	1.21	1.03
48.45	10.82	601.79	12.15	12.42	1.13	1.02
49.52	10.51	613.12	12.12	12.37	1.07	1.02
50.60	10.59	624.44	12.08	12.32	1.08	0.96
51.68	10.49	635.73	12.05	12.27	1.30	1.00
52.75	10.55	646.93	12.02	12.23	1.18	1.02
53.83	10.28	657.84	11.98	12.18	1.20	1.04
54.90	10.02	668.86	11.95	12.13	0.91	0.92
55.98	10.49	679.79	11.92	12.08	1.31	1.03
57.05	9.86	690.24	11.88	12.03	1.16	1.00
58.12	9.58	700.27	11.83	11.97	1.19	1.03
59.20	9.07	709.23	11.77	11.89	1.10	0.91
60.27	7.85	716.87	11.69	11.79	0.98	0.86
61.35	6.53	723.48	11.59	11.67	0.72	0.81
62.42	5.79	729.12	11.48	11.54	0.59	0.85
63.49	4.72	733.72	11.36	11.40	0.69	0.84
64.57	3.84	737.23	11.25	11.24	0.68	0.90
65.64	2.70	739.91	11.09	11.07	0.22	0.74
66.72	2.28	742.03	10.95	10.90	0.21	0.85
67.79	1.88	743.72	10.80	10.73	0.15	0.87
68.86	1.46	744.87	10.65	10.55	0.36	1.07
69.94	0.68	745.39	10.50	10.37	0.16	1.06
71.01	0.30	745.62	10.34	10.19	0.07	1.06
72.09	0.12	745.69	10.19	10.02	0.03	1.02
73.16	0.01	745.70	10.04	9.85	0.01	2.00
74.24	0.00	745.70	9.90	9.69	0.00	2.00
75.32	0.00	745.70	9.78	9.53	0.01	2.00
76.39	0.	745.70	9.65	9.37	0.	0.
77.47	0.	0.	0.	0.	0.	0.

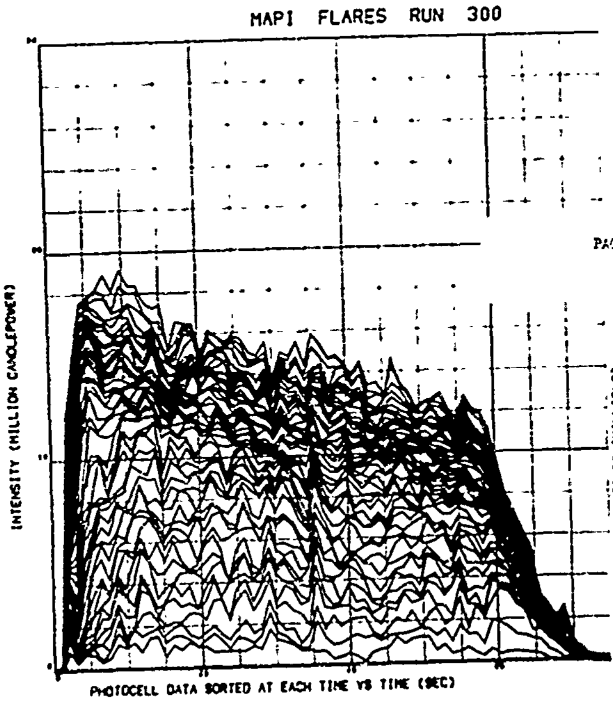
MAPI FLARES RUN 300



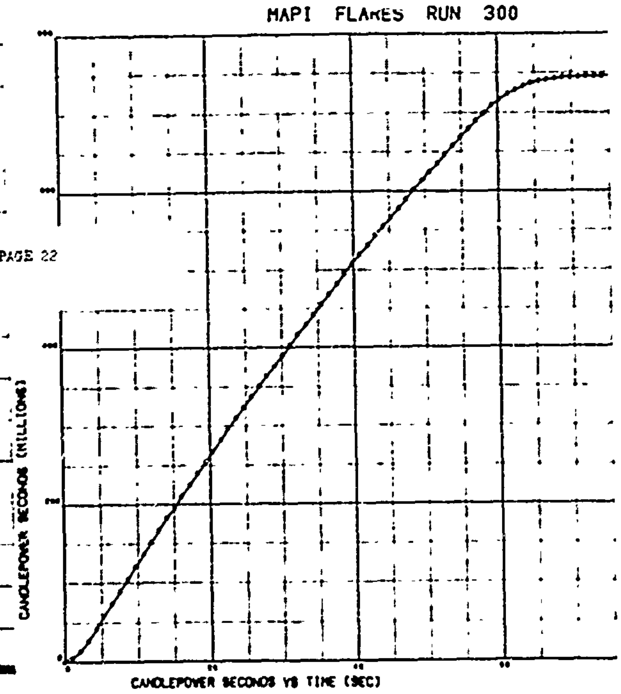
MAPI FLARES RUN 300



MAPI FLARES RUN 300



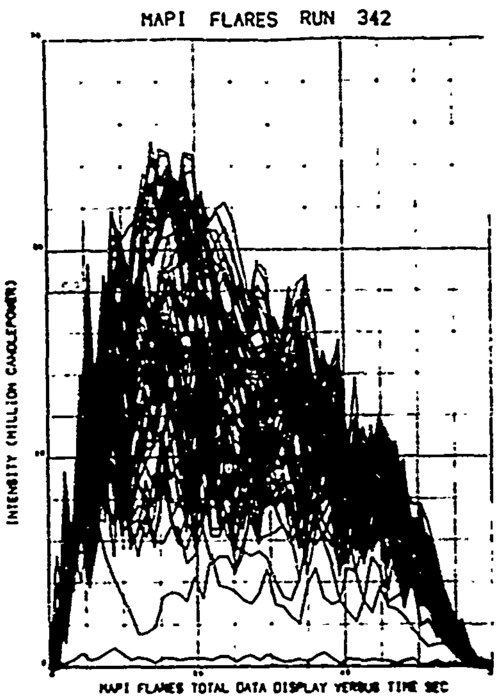
MAPI FLARES RUN 300

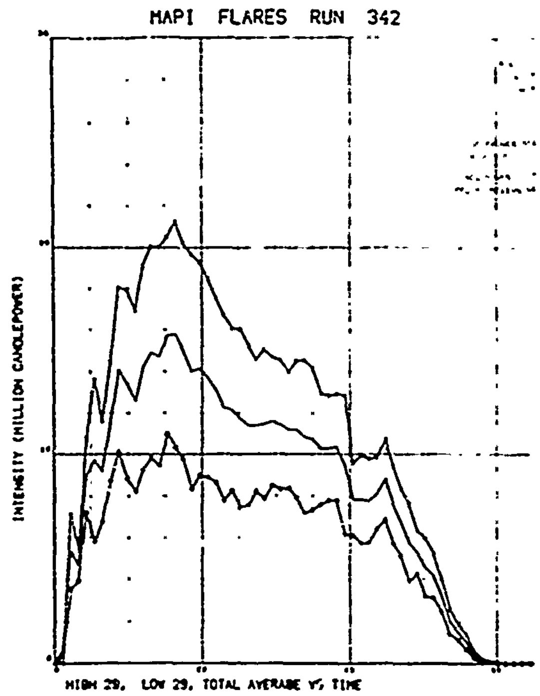


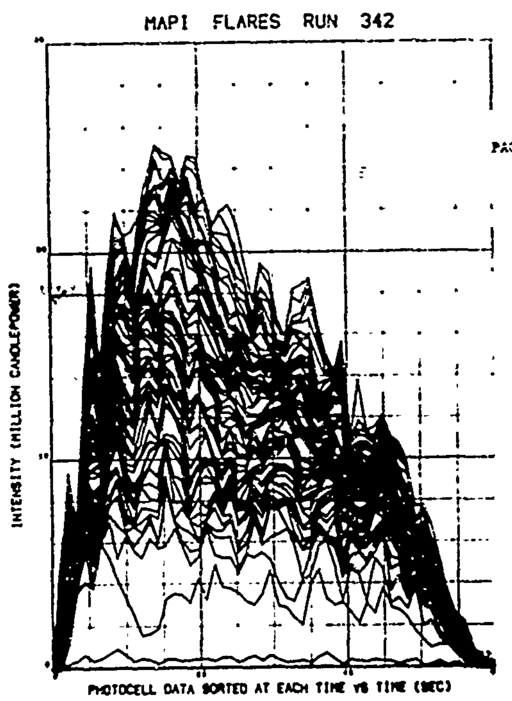
NAPI FLARES RUN 342

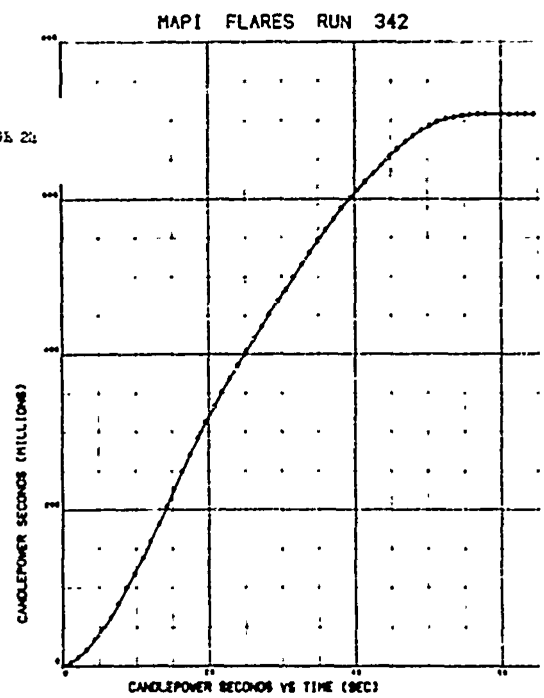
INSTANTANEOUS TIME, AVERAGE OF HIGH 29 PHOTOCELLS, INTEGRATED CANDLEPOWER SECONDS FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME ZERO. RUNNING MEAN CANDLEPOWER FROM TIME 10, STANDARD DEVIATION OF HIGH 29 PHOTOCELLS, UNIFORMITY FACTOR

TIME (SEC)	HIGH 29 AVG	CP-SEC	AVG CP 0 SEC	AVG CP 10 SEC	STD DEV	U
0.	0.03	0.38	0.38	0.	0.92	2.00
1.09	6.68	4.64	2.13	0.	1.24	1.94
2.18	7.12	11.49	3.51	0.	0.94	0.67
3.27	5.43	25.34	4.66	0.	0.40	0.32
4.37	10.79	33.68	6.17	0.	1.21	0.40
5.46	13.60	47.35	7.23	0.	2.90	0.80
6.55	11.60	61.57	8.06	0	1.39	0.52
7.64	14.48	79.36	9.09	0.	2.18	0.50
8.73	19.07	99.10	10.09	0.	1.87	0.56
9.82	17.96	119.19	10.82	0.	2.11	0.66
10.92	16.94	137.93	11.48	18.03	1.82	0.69
12.01	19.11	159.35	12.16	18.90	2.11	0.69
13.11	20.04	181.31	12.77	19.21	2.46	0.65
14.20	20.04	203.53	13.30	19.48	3.22	0.72
15.30	20.51	226.39	13.81	19.76	2.29	0.61
16.39	21.25	249.08	14.24	19.92	2.63	0.69
17.49	20.23	270.93	14.58	19.93	2.42	0.70
18.59	19.67	292.21	14.95	19.87	3.30	0.81
19.68	19.28	312.84	15.06	19.76	2.71	0.73
20.77	18.48	332.55	15.21	19.59	2.86	0.70
21.86	17.55	351.32	15.30	19.36	2.50	0.69
22.96	16.72	369.26	15.35	19.12	2.52	0.75
24.05	16.10	386.56	15.38	18.98	2.69	0.65
25.15	16.05	403.93	15.40	18.65	2.14	0.73
26.24	15.25	420.30	15.39	18.40	2.05	0.64
27.33	14.57	436.48	15.35	18.13	1.55	0.56
28.43	15.05	452.74	15.34	17.99	2.06	0.63
29.52	14.69	468.78	15.31	17.80	1.76	0.53
30.62	14.53	484.39	15.27	17.61	1.03	0.54
31.71	14.00	499.84	15.24	17.44	1.07	0.59
32.80	14.50	515.63	15.22	17.31	1.66	0.59
33.88	14.55	531.33	15.19	17.17	1.69	0.68
34.98	14.14	546.17	15.14	17.01	2.25	0.64
36.07	12.94	563.29	15.07	16.84	1.73	0.52
37.17	12.79	574.35	15.01	16.68	1.11	0.43
38.27	12.09	588.46	14.95	16.53	1.07	0.50
39.36	12.82	600.74	14.85	16.33	1.46	0.70
40.46	9.56	611.35	14.71	16.10	0.85	0.44
41.55	9.95	622.14	14.59	15.89	1.14	0.54
42.64	9.80	632.77	14.47	15.69	0.92	0.52
43.73	9.84	643.96	14.37	15.51	0.65	0.42
44.81	10.72	654.94	14.27	15.34	0.74	0.44
45.91	9.38	664.65	14.14	15.14	0.85	0.49
47.00	8.30	673.33	14.00	14.93	1.11	0.47
48.10	7.59	680.92	13.84	14.70	1.04	0.64
49.19	6.31	687.64	13.67	14.47	0.41	0.39
50.29	5.94	693.75	13.50	14.23	0.96	0.61
51.38	4.23	698.81	13.32	13.97	0.60	0.51
52.47	4.00	702.41	13.11	13.70	0.44	0.49
53.57	2.56	704.79	12.89	13.41	0.35	0.58
54.66	1.83	706.54	12.67	13.12	0.19	0.49
55.75	1.39	707.64	12.45	12.84	0.34	0.68
56.84	0.61	708.07	12.22	12.55	0.13	0.73
57.94	0.18	708.28	11.79	12.00	0.03	1.20
60.10	0.02	708.29	11.58	11.74	0.03	2.00
61.19	0.01	708.30	11.37	11.49	0.01	2.00
62.28	0.01	708.32	11.18	11.25	0.03	2.00
63.38	0.02	708.34	10.99	11.02	0.03	2.00
64.47	0.02	708.35	10.80	10.80	0.02	2.00
65.56	0.00	0.	0.	0.	0.01	2.00


MAPI FLARES RUN 342
INTENSITY (MILLION CANDLEPOWER)
MAPI FLARES TOTAL DATA DISPLAY VERSUS TIME SEC


MAPI FLARES RUN 342
INTENSITY (MILLION CANDLEPOWER)
HIGH 29, LOW 29, TOTAL AVERAGE VS TIME


MAPI FLARES RUN 342
INTENSITY (MILLION CANDLEPOWER)
PHOTOCELL DATA SORTED AT EACH TIME VS TIME (SEC)

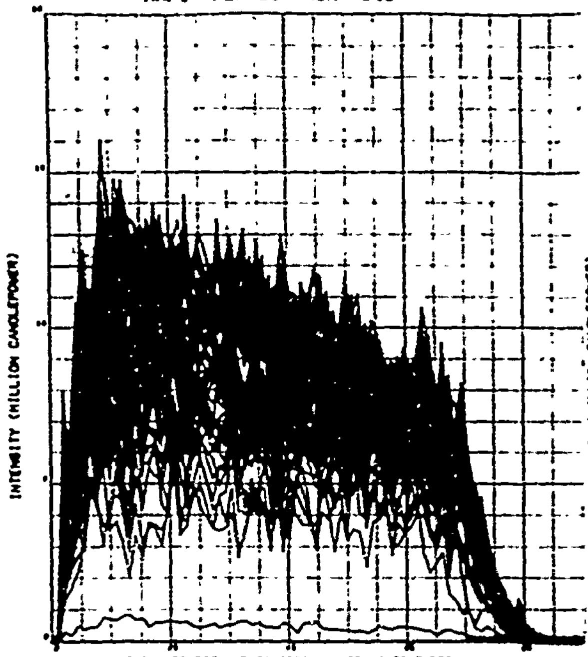

MAPI FLARES RUN 342
CANDLEPOWER SECONDS (MILLIONS)
CANDLEPOWER SECONDS VS TIME (SEC)

NAPI FLARES RUN 343

INSTANTANEOUS TIME, AVERAGE OF HIGH 29 PHOTOCELLS, INTEGRATED CANDLEPOWER SECONDS FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME 10, STANDARD DEVIATION OF HIGH 29 PHOTOCELLS, UNIFORMITY FACTOR

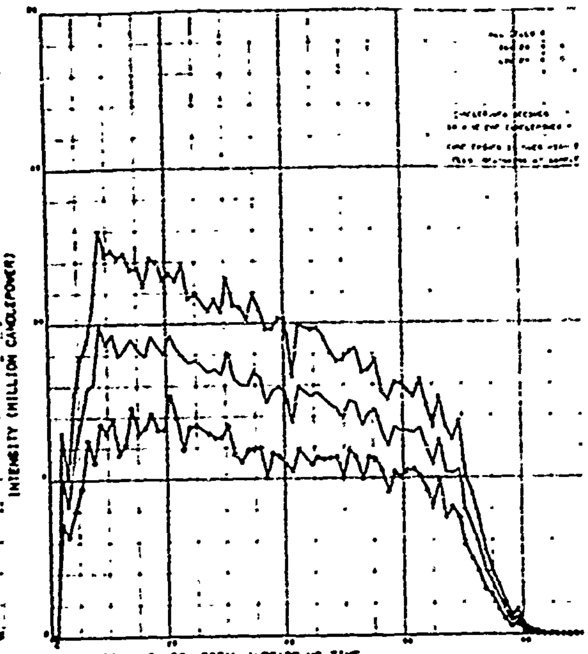
TIME (SEC)	HIGH 29 AVG	CP-SEC	AVG CP 0 SEC	AVG CP 10 SEC	STD DEV	U
0.	0.09	0.08	0.05	0.	0.03	1.81
1.00	0.01	3.61	1.66	0.	0.02	2.00
2.18	6.50	9.89	3.03	0.	0.45	0.58
3.26	5.06	16.87	3.88	0.	0.71	0.48
4.35	7.77	25.93	4.77	0.	1.48	0.64
5.44	8.90	35.90	5.50	0.	1.87	0.61
6.53	9.45	46.81	6.15	0.	0.88	0.40
7.61	10.84	59.68	6.88	0.	1.03	0.85
8.70	13.10	73.40	7.30	0.	1.25	0.64
9.78	12.21	86.72	7.93	0.	0.80	0.61
10.86	12.38	100.02	8.37	12.25	1.03	0.56
11.95	12.13	113.28	8.69	12.23	1.74	0.71
13.04	12.26	126.33	8.95	12.16	0.91	0.67
14.12	11.77	139.15	9.15	12.07	0.79	0.47
15.21	11.82	151.85	9.31	11.96	0.82	0.58
16.29	11.23	164.30	9.45	11.91	1.25	0.51
17.38	12.12	177.42	9.61	11.93	0.85	0.52
18.47	12.02	190.18	9.73	11.91	0.88	0.58
19.55	11.43	202.70	9.82	11.86	0.75	0.53
20.64	11.61	215.20	9.91	11.83	0.75	0.41
21.73	11.41	227.87	9.99	11.82	0.90	0.48
22.81	11.95	240.20	10.05	11.73	1.23	0.67
23.90	10.79	252.02	10.09	11.71	0.71	0.45
24.98	10.57	273.30	10.14	11.57	1.00	0.48
27.16	10.41	286.82	10.15	11.51	0.71	0.47
28.25	10.75	298.38	10.17	11.48	1.42	0.52
29.34	10.39	310.27	10.20	11.43	0.77	0.42
30.43	11.45	322.28	10.22	11.40	1.08	0.52
31.52	10.59	333.78	10.24	11.36	0.70	0.59
32.61	10.53	345.02	10.24	11.31	1.29	0.62
33.70	10.12	356.48	10.25	11.28	0.93	0.53
34.79	10.94	368.14	10.26	11.25	1.23	0.59
35.88	10.46	379.16	10.26	11.20	1.05	0.54
36.96	9.81	389.82	10.24	11.15	1.19	0.64
38.05	9.82	400.67	10.24	11.10	0.70	0.51
39.14	10.15	411.69	10.24	11.07	1.35	0.56
40.22	10.14	421.72	10.21	11.00	0.84	0.60
41.31	8.31	431.82	10.18	10.94	1.28	0.45
42.40	9.94	453.02	10.17	10.87	0.85	0.51
44.58	9.81	463.68	10.16	10.84	0.94	0.57
45.65	9.85	474.12	10.15	10.80	1.12	0.53
46.73	9.49	484.18	10.13	10.76	0.99	0.51
47.81	9.06	493.81	10.10	10.71	0.80	0.46
49.89	8.78	503.38	10.07	10.65	0.37	0.43
49.98	8.84	513.08	10.05	10.61	1.15	0.55
51.06	9.10	522.97	10.03	10.57	0.71	0.43
52.14	9.17	532.50	10.00	10.52	0.94	0.47
53.22	8.44	541.64	9.97	10.47	0.83	0.52
54.30	8.50	551.00	9.95	10.43	0.68	0.40
55.39	8.80	559.88	9.92	10.38	0.44	0.45
56.47	7.78	568.27	9.87	10.31	0.58	0.39
57.55	7.53	578.72	9.84	10.28	0.68	0.49
58.64	8.07	585.43	9.80	10.21	0.45	0.44
59.72	8.04	594.01	9.77	10.16	0.82	0.48
60.80	7.84	602.35	9.73	10.11	0.44	0.40
61.88	7.61	610.87	9.70	10.06	0.65	0.37
62.96	8.15	619.26	9.67	10.01	1.14	0.47
64.04	7.34	626.83	9.63	9.95	1.01	0.46
65.12	6.66	634.58	9.58	9.90	0.42	0.46
66.21	7.60	642.27	9.54	9.85	0.85	0.43
67.29	6.65	649.24	9.50	9.78	0.79	0.57
68.37	6.24	656.30	9.45	9.72	0.44	0.42
69.45	6.81	662.70	9.40	9.65	0.68	0.58
70.53	5.02	667.84	9.33	9.57	0.41	0.56
71.62	4.49	672.29	9.25	9.47	0.33	0.60
72.70	3.75	675.80	9.16	9.36	0.38	0.60
73.78	2.72	678.40	9.08	9.24	0.28	0.62
74.87	2.08	680.38	8.96	9.12	0.15	0.50
75.95	1.58	681.78	8.85	8.99	0.13	0.64
77.03	1.00	682.65	8.74	8.86	0.15	0.67
78.12	0.60	683.41	8.63	8.73	0.17	0.83
79.20	0.79	684.02	8.52	8.60	0.27	0.80
80.29	0.34	684.29	8.41	8.48	0.08	0.90
81.37	0.15	684.42	8.30	8.35	0.08	1.52
82.45	0.10	684.50	8.19	8.23	0.04	1.59
83.53	0.05	684.54	8.09	8.11	0.03	1.99
84.62	0.01	684.54	7.99	7.99	0.02	2.00
85.71	0.00	684.55	7.89	7.87	0.00	2.00
86.79	0.	684.55	7.79	7.76	0.	0.
87.87	0.00	684.55	7.70	7.66	0.01	2.00
88.95	0.00	684.55	7.60	7.55	0.00	2.00
90.03	0.00	684.58	7.51	7.45	0.01	2.00
91.11	0.04	0.	0.	0.	0.03	2.00

MAPI FLARES RUN 343



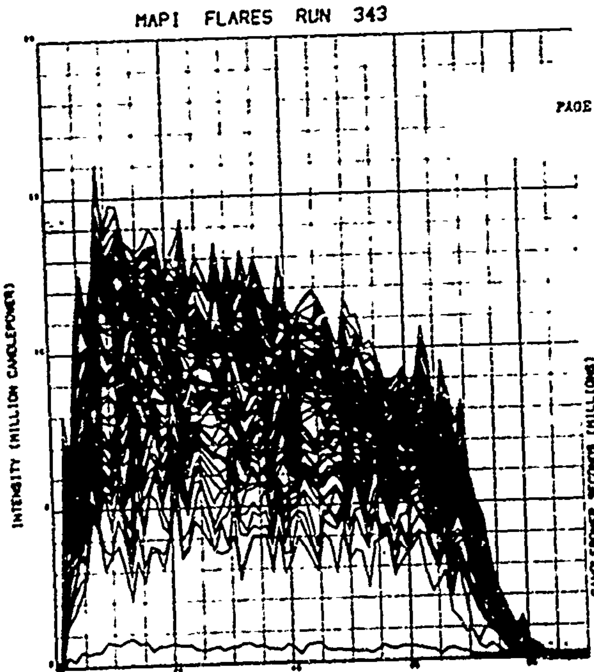
MAPI FLARES TOTAL DATA DISPLAY VERSUS TIME SEC

MAPI FLARES RUN 343



HIGH 29, LOW 29, TOTAL AVERAGE VS TIME

MAPI FLARES RUN 343



PHOTOCELL DATA SORTED AT EACH TIME VS TIME (SEC)

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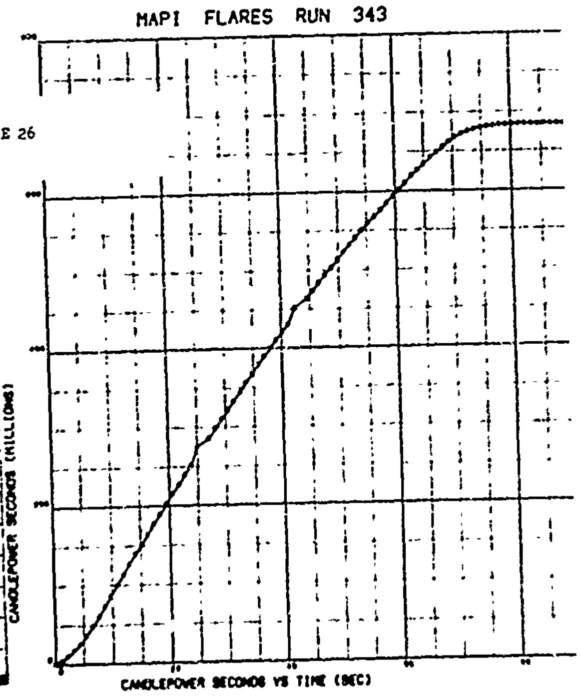
MAPI FLARES RUN 343

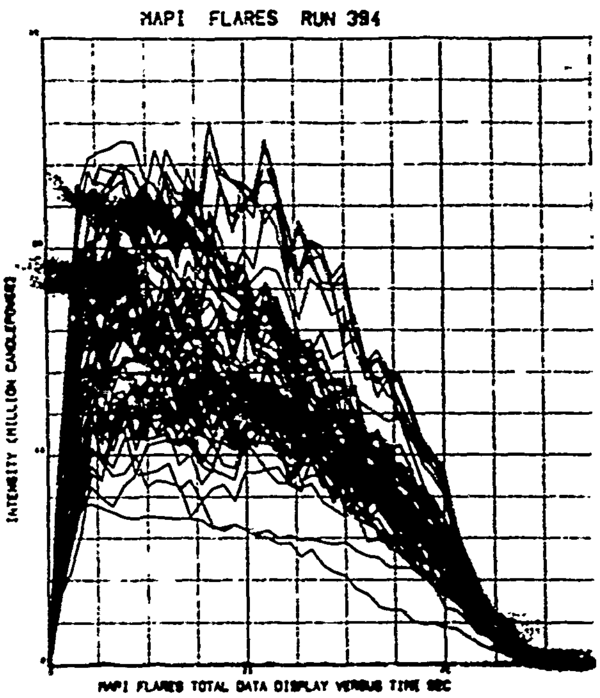


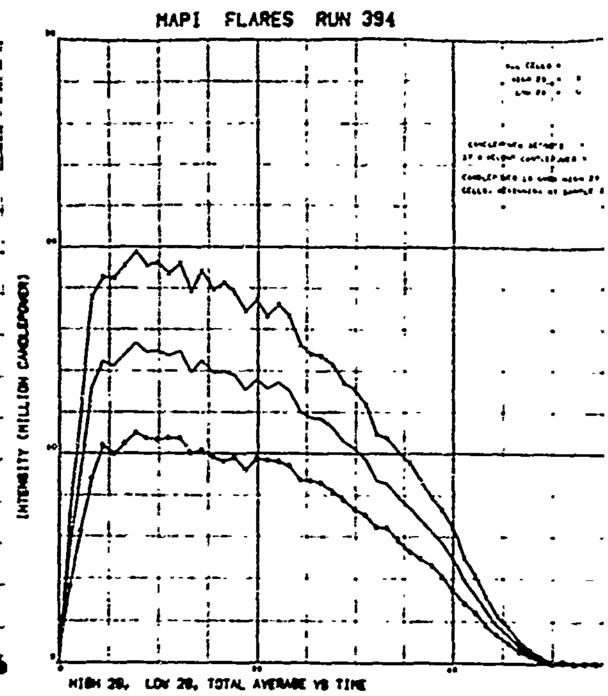
CANDLEPOWER SECONDS VS TIME (SEC)

NAPI FLARES RUN-394

INSTANTANEOUS TIME, AVERAGE OF HIGH 29 PHOTOCELLS, INTEGRATED CANDLEPOWER SECONDS FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME 10, STANDARD DEVIATION OF HIGH 29 PHOTOCELLS, UNIFORMITY FACTOR

TIME (SEC)	HIGH 29 AVG	CP-SEC	AVG CP 0 SEC	AVG CP 10 SEC	STD DEV	U
0.	0.00	3.83	3.51	0.	0.01	2.00
1.09	7.03	14.24	6.53	0.	1.23	0.84
2.18	12.06	30.22	9.27	0.	1.88	0.83
3.26	17.58	49.82	11.47	0.	2.89	0.87
4.34	18.54	70.23	12.89	0.	2.62	0.58
5.45	18.49	91.18	13.90	0.	2.92	0.60
6.56	19.30	112.84	14.70	0.	2.79	0.58
7.68	19.76	134.49	15.30	0.	2.86	0.57
8.79	19.11	155.73	15.74	0.	2.55	0.58
9.90	19.25	176.71	16.06	0.	2.73	0.57
11.00	18.70	197.72	16.32	0.	2.75	0.54
12.11	19.19	218.20	16.51	18.94	2.76	0.56
13.22	17.87	238.69	16.65	18.74	2.68	0.56
14.33	18.83	259.17	16.78	18.61	2.98	0.80
15.45	17.95	279.42	16.87	18.55	2.79	0.59
16.57	18.25	299.36	16.94	18.46	3.48	0.62
17.67	17.77	318.63	16.96	19.39	3.19	0.58
18.79	16.87	337.62	16.97	18.23	2.96	0.59
19.90	17.41	356.65	16.97	18.10	2.98	0.56
21.01	16.64	375.54	16.97	17.98	3.04	0.53
22.13	17.24	394.40	16.97	17.57	3.58	0.57
23.24	16.66	412.20	16.93	17.79	3.40	0.56
24.35	15.29	429.05	16.64	17.64	2.67	0.55
25.47	14.81	445.53	16.76	17.44	2.49	0.52
26.59	14.74	461.79	16.67	17.25	2.75	0.53
27.71	14.28	477.31	16.56	17.06	2.63	0.54
28.83	13.40	492.17	16.43	16.88	2 52	0.53
29.95	13.08	506.42	16.30	16.65	2.56	0.56
31.0.	12.37	519.49	16.14	16.43	2.07	0.55
32.19	10.93	531.67	15.98	16.18	1.82	0.51
33.32	10.73	543.21	15.78	15.91	1.91	0.51
34.43	10.08	554.12	15.59	15.61	2.01	0.54
35.54	9.55	564.31	15.40	15.36	2.01	0.58
36.65	8.74	573.56	15.19	15.11	1.70	0.56
37.77	7.89	582.03	14.97	14.83	1.34	0.52
38.88	7.32	589.71	14.75	14.54	1.26	0.56
39.99	6.47	596.09	14.50	14.25	1.32	0.81
41.11	4.98	601.15	14.24	13.93	0.77	0.55
42.22	4.13	605.18	13.97	13.60	0.48	0.54
43.33	3.14	608.14	13.69	13.26	0.34	0.56
44.43	2.22	610.29	13.40	12.91	0.22	0.51
45.53	1.69	611.82	13.12	12.56	0.19	0.54
46.64	1.06	612.76	12.83	12.21	0.14	0.81
47.75	0.65	613.28	12.55	11.87	0.09	0.50
48.85	0.29	613.45	12.28	11.53	0.05	0.83
49.96	0.03	613.53	12.01	11.21	0.03	2.00
51.06	0.11	613.59	11.76	10.90	0.03	1.05
52.17	0.01	613.60	11.52	10.61	0.02	2.00
53.27	0.00	613.62	11.28	10.34	0.00	2.00
54.38	0.05	613.65	11.08	10.07	0.05	1.95
55.50	0.01	613.66	10.84	9.82	0.02	2.00
56.60	0.01	613.68	10.63	9.58	0.02	2.00
57.71	0.01	0.	0.	9.36	0.02	2.00


MAPI FLARES RUN 394
INTENSITY (MILLION CANDLEPOWER)
MAPI FLARES TOTAL DATA DISPLAY VERSUS TIME SEC


MAPI FLARES RUN 394
INTENSITY (MILLION CANDLEPOWER)
HIGH 28, LOW 28, TOTAL AVERAGE VS TIME

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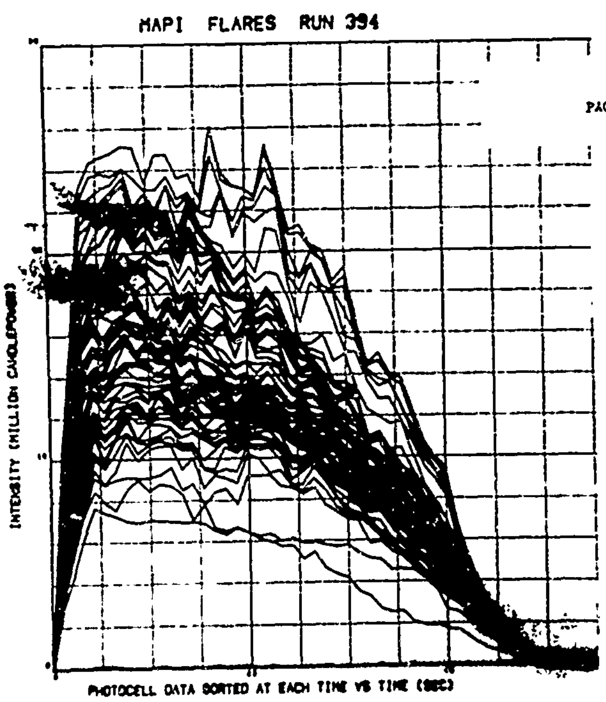
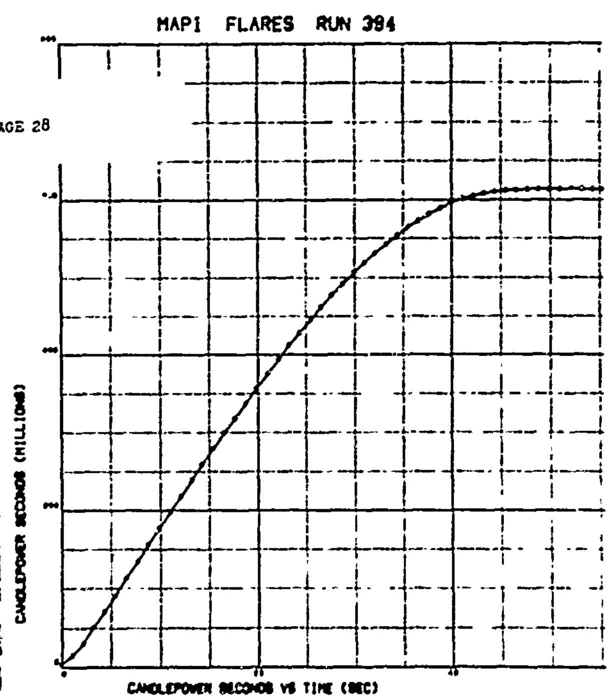

MAPI FLARES RUN 394
INTENSITY (MILLION CANDLEPOWER)
PHOTOCELL DATA SORTED AT EACH TIME VS TIME (SEC)

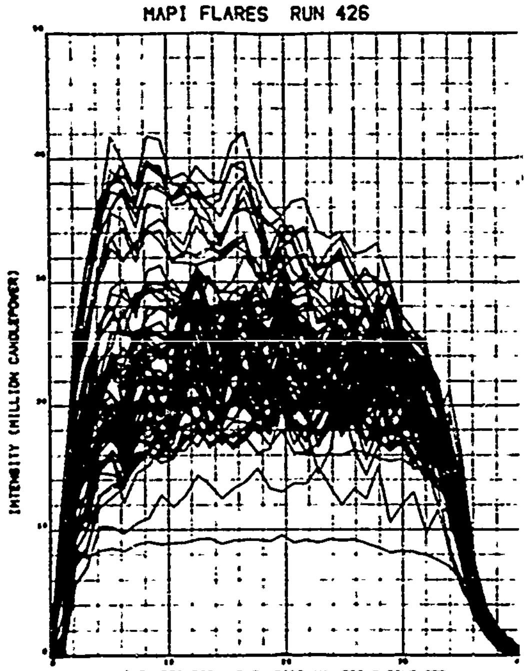

MAPI FLARES RUN 394
CANDLEPOWER SECONDS (MILLIONS)
CANDLEPOWER SECONDS VS TIME (SEC)

NAPI FLARES RUN 428

INSTANTANEOUS TIME, AVERAGE OF HIGH 29 PHOTOCELLS, INTEGRATED CANDLEPOWER SECONDS FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME 10. STANDARD DEVIATION OF HIGH 29 PHOTOCELLS,UNIFORMITY FACTOR

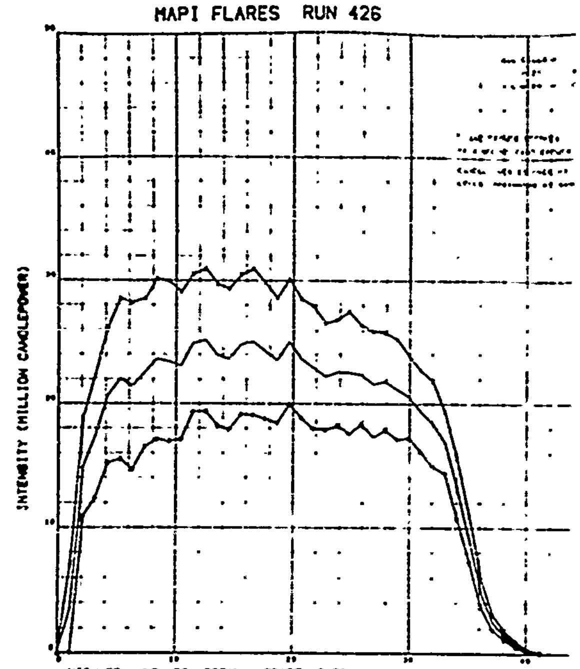
TIME (SEC)	HIGH 29 AVG	CP-SEC	AVG CP 0 SEC	AVG CP 10 SEC	STD DEV	U
0.	0.00	3.78	3.61	0.	0.00	2.00
1.04	7.22	17.31	8.30	0.	3.95	1.96
2.09	18.79	38.71	12.37	0.	2.82	0.53
3.13	22.25	64.04	15.34	0.	4.59	0.57
4.17	26.16	92.62	17.74	0.	5.50	0.53
5.22	28.55	122.28	19.52	0.	6.37	0.59
6.26	28.23	151.99	20.79	0.	6.72	0.63
7.31	28.54	182.48	21.86	0.	4.99	0.53
8.35	30.17	213.70	22.76	0.	5.88	0.55
9.39	29.93	244.36	23.44	0.	5.92	0.55
10.43	29.11	275.44	24.02	29.81	5.10	0.52
11.47	30.51	307.05	24.57	30.27	4.03	0.45
12.50	30.96	337.77	25.00	30.30	3.95	0.46
13.51	29.73	367.89	25.32	30.11	4.23	0.48
14.53	29.37	398.48	25.62	30.07	4.09	0.48
15.55	30.46	430.17	25.94	30.18	4.64	0.46
16.58	30.97	461.53	26.20	30.21	4.83	0.47
17.62	29.84	491.59	26.37	30.03	3.94	0.46
18.64	28.62	521.75	26.52	30.01	3.15	0.43
19.67	30.10	551.76	26.60	29.94	2.77	0.41
20.70	28.49	580.78	26.74	29.78	3.47	0.41
21.72	27.96	608.95	26.76	29.57	3.54	0.44
22.76	26.54	636.55	26.76	29.35	3.03	0.39
23.79	26.86	664.66	26.77	29.19	3.04	0.38
24.82	27.50	692.53	26.78	29.04	3.31	0.42
25.86	26.39	719.58	26.76	28.86	2.48	0.36
26.89	25.91	746.17	26.72	28.66	2.90	0.40
27.92	25.79	772.20	26.68	28.51	2.56	0.36
28.94	25.22	797.34	26.61	28.33	2.46	0.38
29.97	23.35	821.14	26.50	28.05	1.44	0.33
30.99	22.72	844.08	26.37	27.78	1.70	0.34
32.01	21.89	865.37	26.19	27.45	1.77	0.38
33.05	19.35	883.40	25.92	27.02	1.36	0.30
34.08	15.61	897.10	25.55	26.45	1.67	0.37
35.11	10.97	905.75	25.06	25.73	1.46	0.41
36.14	5.87	910.31	24.50	24.91	0.55	0.45
37.16	3.04	912.75	23.91	24.08	0.32	0.47
38.18	1.74	914.00	23.32	23.28	0.16	0.49
39.19	0.88	914.67	22.75	22.51	0.09	0.57
40.21	0.28	914.86	22.19	21.77	0.04	0.73
41.23	0.10	0.	0.	0.	0.04	1.27

MAPI FLARES RUN 426



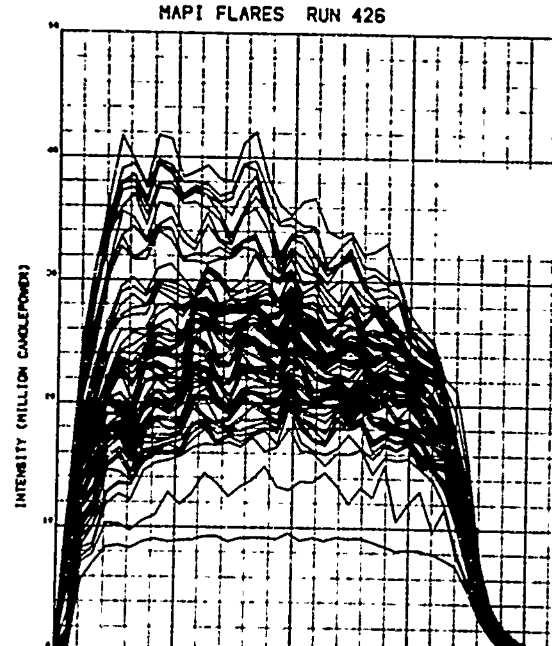
MAPI FLARES TOTAL DATA DISPLAY VERSUS TIME SEC

MAPI FLARES RUN 426



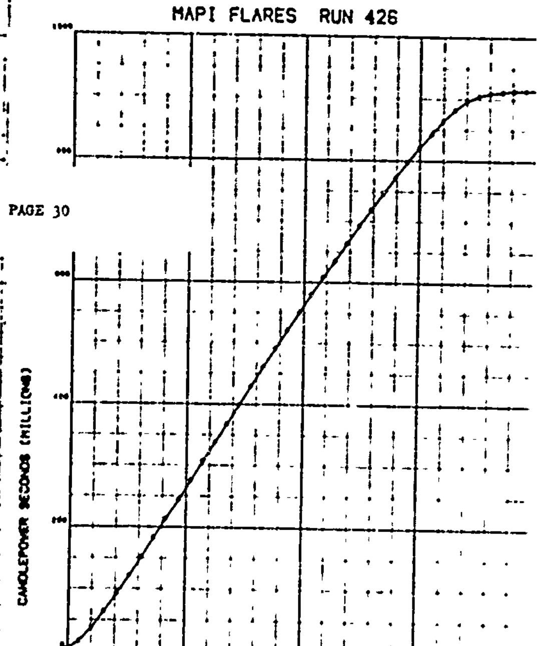
HIGH 29, LOW 29, TOTAL AVERAGE VS TIME

MAPI FLARES RUN 426



PHOTOCELL DATA SORTED AT EACH TIME VS TIME (SEC)

MAPI FLARES RUN 426

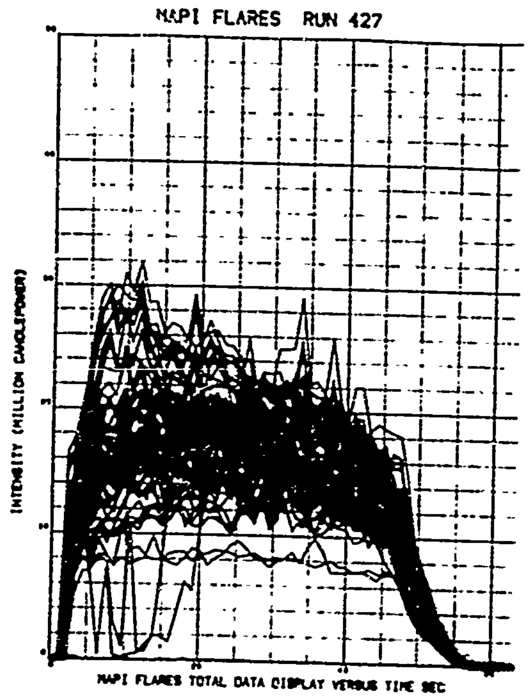


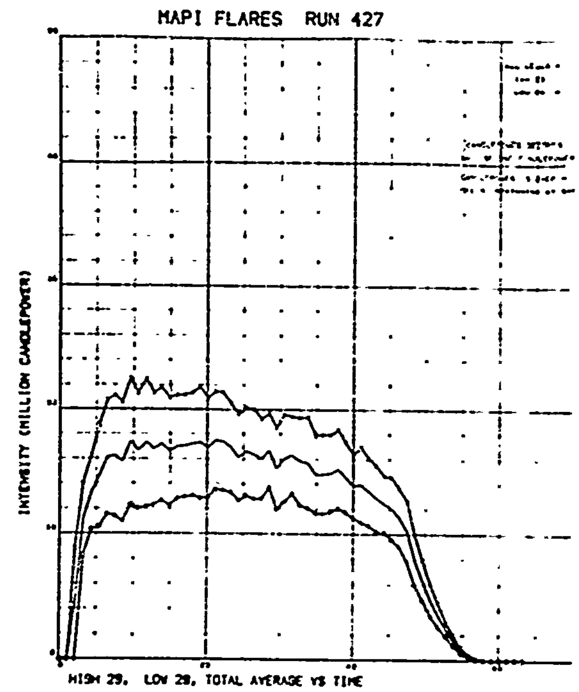
CANDLEPOWER SECONDS VS TIME (SEC)

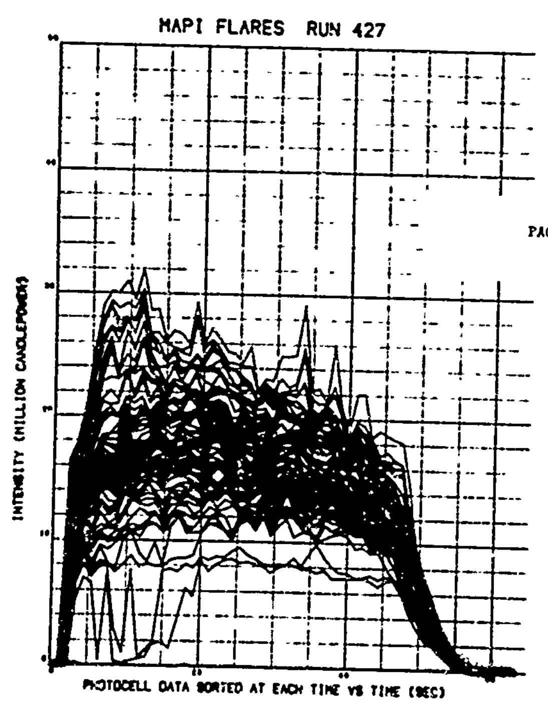
NAPI FLARES RUN 427

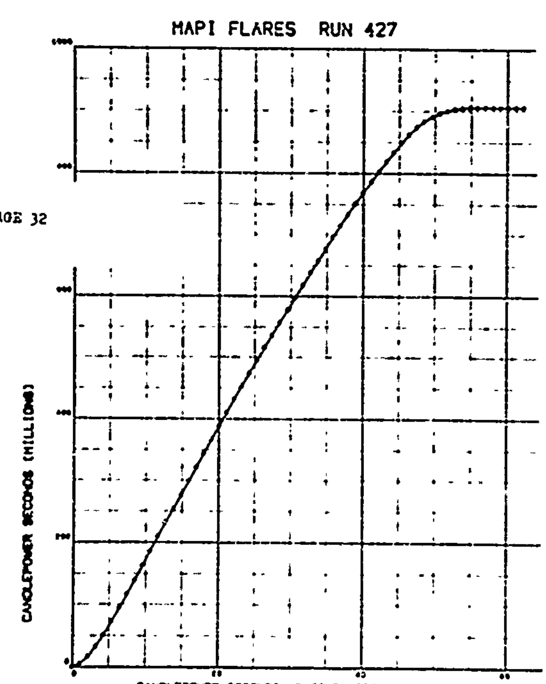
INSTANTANEOUS TIME, AVERAGE OF HIGH 29 PHOTOCELLS, INTEGRATED CANDLEPOWER SECONDS FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME 10, STANDARD DEVIATION OF HIGH 29 PHOTOCELLS, UNIFORMITY FACTOR

TIME (SEC)	HIGH 29 AVG	CP-SEC	AVG CP 0 SEC	AVG CP 10 SEC	STD DEV	U
0.	0.00	0.02	0.02	0.	0.01	2.00
1.07	0.03	4.73	2.22	0.	0.03	2.00
2.13	8.85	16.90	5.28	0.	4.41	2.00
3.20	14.03	33.04	7.75	0.	1.96	0.52
4.26	16.24	51.82	9.69	0.	2.16	0.45
5.33	18.69	72.74	11.37	0.	3.20	0.56
6.40	20.73	94.86	12.72	0.	4.17	0.57
7.45	21.10	116.83	13.73	0.	4.93	0.60
8.51	20.57	139.55	14.59	0.	4.46	0.61
9.57	22.53	162.81	15.32	0.	3.81	0.59
10.63	21.36	185.97	15.92	21.92	4.24	0.56
11.68	22.48	209.13	16.41	21.91	4.83	0.60
12.74	21.32	231.94	16.82	21.73	3.40	0.54
13.80	21.79	254.56	17.13	21.69	2.77	0.53
14.86	20.96	276.95	17.40	21.56	2.46	0.52
15.92	21.19	299.30	17.63	21.50	2.87	0.49
16.97	21.19	321.60	17.85	21.47	2.38	0.48
18.02	21.37	344.08	18.05	21.49	2.41	0.48
19.06	21.79	366.35	18.22	21.47	3.10	0.52
20.11	20.90	388.48	18.37	21.44	2.45	0.47
21.15	21.45	410.96	18.51	21.44	2.46	0.45
22.20	21.37	432.98	18.62	21.40	2.38	0.45
23.25	20.55	454.10	18.68	21.30	2.28	0.43
24.30	19.60	474.95	18.73	21.20	2.63	0.43
25.35	20.22	496.03	18.79	21.12	2.02	0.43
26.40	19.98	516.68	18.82	21.03	2.11	0.44
27.45	19.28	537.15	18.85	20.94	1.59	0.40
28.50	19.67	557.23	18.85	20.84	1.80	0.36
29.55	18.55	577.28	18.86	20.75	2.03	0.43
30.60	19.61	597.77	18.88	20.68	2.30	0.44
31.66	19.40	618.18	18.90	20.62	2.13	0.38
32.71	19.38	638.60	18.91	20.56	2.14	0.45
33.76	19.35	658.24	18.91	20.48	3.30	0.47
34.82	17.89	677.09	18.88	20.37	1.92	0.42
35.87	17.96	696.05	18.85	20.28	2.17	0.43
36.92	17.96	715.17	18.83	20.20	2.29	0.42
37.98	18.40	733.95	18.81	20.11	2.39	0.42
39.03	17.39	751.74	18.76	20.00	1.70	0.39
40.08	16.36	769.31	18.70	19.88	1.24	0.37
41.13	16.95	786.71	18.65	19.77	2.23	0.43
42.19	16.11	803.40	18.58	19.64	2.13	0.40
43.24	15.49	819.32	18.50	19.50	1.64	0.41
44.30	14.68	834.74	18.40	19.35	1.49	0.37
4[illegible]	14.54	849.57	18.31	19.19	1.75	0.41
46[illegible]	13.65	863.44	18.19	19.02	1.89	0.41
47.46	12.67	875.38	18.04	18.80	2.35	0.48
48.52	9.93	884.83	17.85	18.54	1.73	0.50
49.58	7.97	892.23	17.62	18.23	0.83	0.50
50.63	6.04	897.81	17.37	17.90	0.77	0.54
51.69	4.51	901.75	17.09	17.54	0.66	0.53
52.75	2.93	904.37	16.81	17.17	0.34	0.44
53.81	2.03	905.98	16.51	16.80	0.24	0.53
54.86	1.00	906.74	16.21	16.42	0.15	0.59
55.93	0.43	907.05	15.92	16.05	0.09	0.59
56.99	0.15	907.15	15.63	15.70	0.05	1.09
58.04	0.04	907.18	15.35	15.36	0.03	2.00
59.10	0.00	907.22	15.09	15.04	0.00	2.00
60.14	0.08	907.30	14.83	14.73	0.03	1.97
61.19	0.07	907.37	14.58	14.43	0.03	1.97
62.23	0.07	907.44	14.34	14.14	0.03	2.00
63.29	0.05	0.	0.	0.	0.03	2.00


MAPI FLARES RUN 427
INTENSITY (MILLION CANDLEPOWER)
MAPI FLARES TOTAL DATA DISPLAY VERSUS TIME SEC


MAPI FLARES RUN 427
INTENSITY (MILLION CANDLEPOWER)
HIGH 29, LOW 29, TOTAL AVERAGE VS TIME


MAPI FLARES RUN 427
INTENSITY (MILLION CANDLEPOWER)
PHOTOCELL DATA SORTED AT EACH TIME VS TIME (SEC)

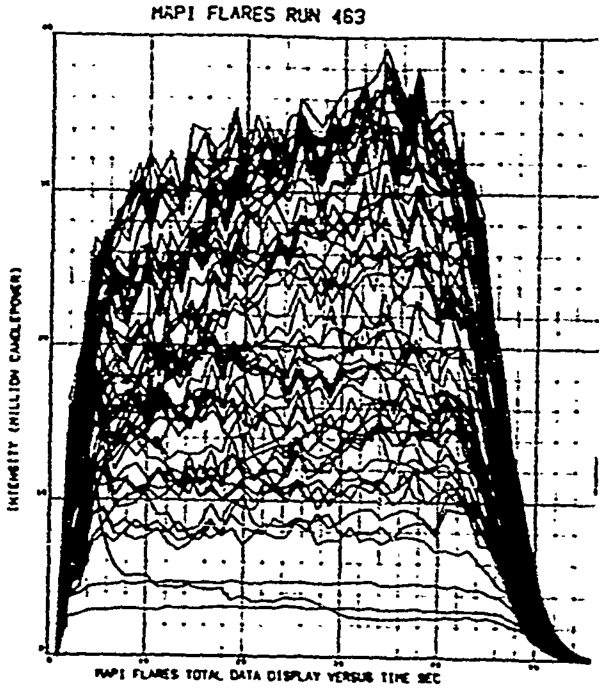

MAPI FLARES RUN 427
CANDLEPOWER SECONDS (MILLIONS)
CANDLEPOWER SECONDS VS TIME (SEC)

NAPI FLARES RUN 463

INSTANTANEOUS TIME, AVERAGE OF HIGH 29 PHOTOCELLS, INTEGRATED CANDLEPOWER SECONDS FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME 10, STANDARD DEVIATION OF HIGH 29 PHOTOCELLS, UNIFORMITY FACTOR

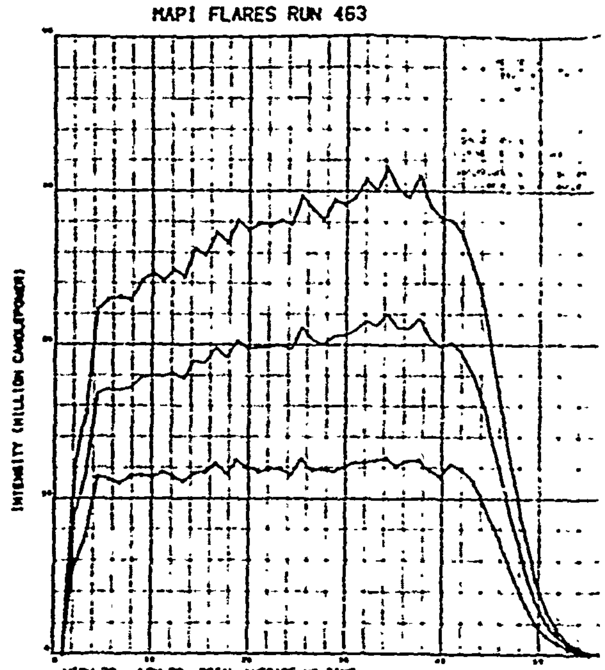
TIME (SEC)	HIGH 29 AVG	CP-SEC	AVG CP 0 SEC	AVG CP 10 SEC	STD DEV	U
.84	.00	6.70	5.95	.00	.00	-.00
2.11	11.41	22.30	9.61	.00	2.08	.69
3.25	15.59	43.69	12.84	.00	2.13	.70
4.34	22.30	69.24	15.28	.00	2.67	.65
5.51	22.98	95.33	16.85	.00	3.20	.69
6.64	23.11	121.13	17.86	.00	3.52	.71
7.75	22.97	147.76	18.65	.00	3.82	.67
8.87	24.18	174.25	19.37	.00	4.27	.71
9.97	24.70	201.14	19.92	.00	3.85	.74
11.07	21.16	228.18	20.30	.00	4.29	.69
12.19	24.51	255.35	20.76	24.69	4.05	.75
13.27	24.48	283.01	21.14	25.03	3.78	.75
14.37	26.27	311.54	21.51	25.33	4.26	.77
15.46	25.89	340.99	21.88	25.69	4.09	.76
16.57	27.14	370.73	22.21	25.96	3.81	.75
17.57	26.69	400.88	22.54	26.20	4.04	.76
18.72	25.14	431.91	22.85	26.44	4.14	.77
19.88	27.53	462.82	23.12	26.60	3.96	.79
21.00	27.35	493.90	23.37	26.75	4.23	.82
22.11	27.85	524.85	23.60	26.87	4.13	.80
23.22	28.11	555.92	23.81	26.97	3.95	.81
24.33	27.92	587.89	24.04	27.13	4.16	.83
25.44	29.72	620.64	24.27	27.30	4.57	.81
26.55	28.87	652.04	24.44	27.38	4.42	.84
27.65	28.16	683.88	24.62	27.48	3.97	.81
28.76	29.17	716.48	24.80	27.61	3.62	.86
29.87	29.16	749.07	24.97	27.70	4.55	.83
30.98	29.67	782.19	25.15	27.84	4.70	.83
32.09	30.79	815.39	25.33	27.90	4.92	.85
33.17	30.07	849.88	25.51	28.12	5.02	.82
34.29	31.53	882.70	25.68	28.24	5.15	.86
35.35	30.14	916.02	25.81	28.32	5.01	.85
36.46	29.64	949.37	25.95	28.41	4.79	.82
37.56	31.09	982.57	26.07	28.47	5.04	.85
38.67	29.00	1014.44	26.14	28.46	4.39	.84
39.78	28.24	1045.82	26.20	28.47	4.69	.85
40.90	28.15	1976.76	26.24	28.44	4.11	.79
42.02	27.18	1105.91	26.24	28.35	3.37	.78
43.13	25.09	1132.40	26.18	28.20	3.58	.77
44.21	22.73	1155.34	26.04	27.95	3.52	.81
45.35	18.71	1173.77	25.82	27.59	2.95	.79
46.45	14.85	1188.01	25.51	27.13	2.44	.78
47.55	10.96	1198.96	25.14	26.60	1.74	.78
48.64	7.40	1204.66	24.71	26.09	1.31	.81
49.73	4.78	1209.76	24.25	25.38	.95	.86
50.82	2.74	1211.12	23.78	24.74	.51	.80
51.91	1.57	1212.39	23.30	24.10	.23	.70
53.01	.76	1212.99	22.84	23.49	.12	.68
54.10	.34	1213.24	22.39	22.91	.06	.68
55.18	.12	1213.35	21.95	22.35	.04	1.38
56.26	.08	1213.40	21.52	21.81	.03	1.59
57.35	.02	.00	.00	.00	.03	2.00

MAPI FLARES RUN 463



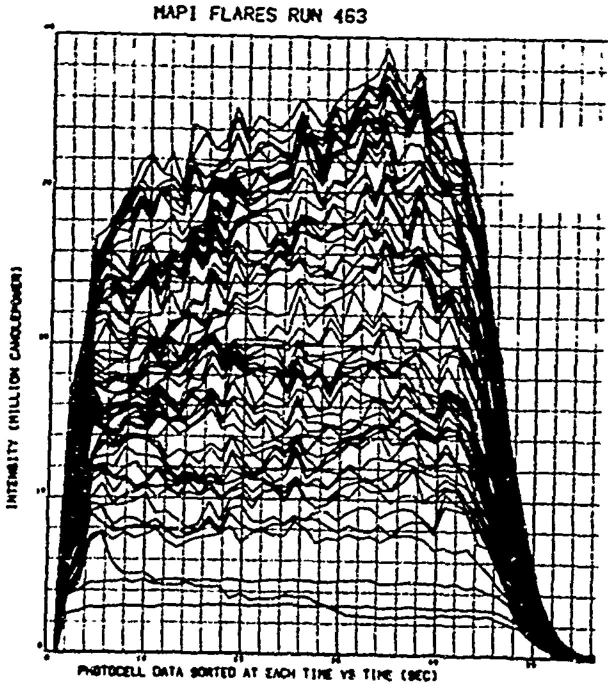
MAPI FLARES TOTAL DATA DISPLAY VERSUS TIME SEC

MAPI FLARES RUN 463



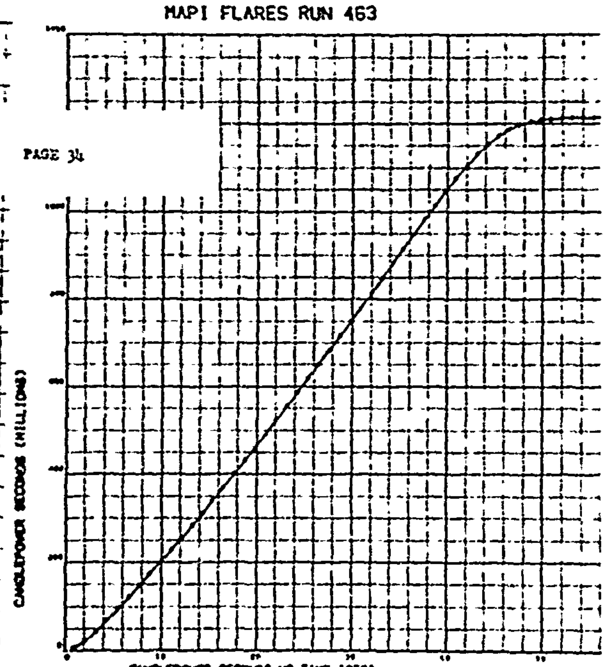
HIGH 29, LOW 29, TOTAL AVERAGE VS TIME

MAPI FLARES RUN 463



PHOTOCELL DATA SORTED AT EACH TIME VS TIME (SEC)

MAPI FLARES RUN 463



CANDLEPOWER SECONDS VS TIME (SEC)

NAPI FLARES RUN 484

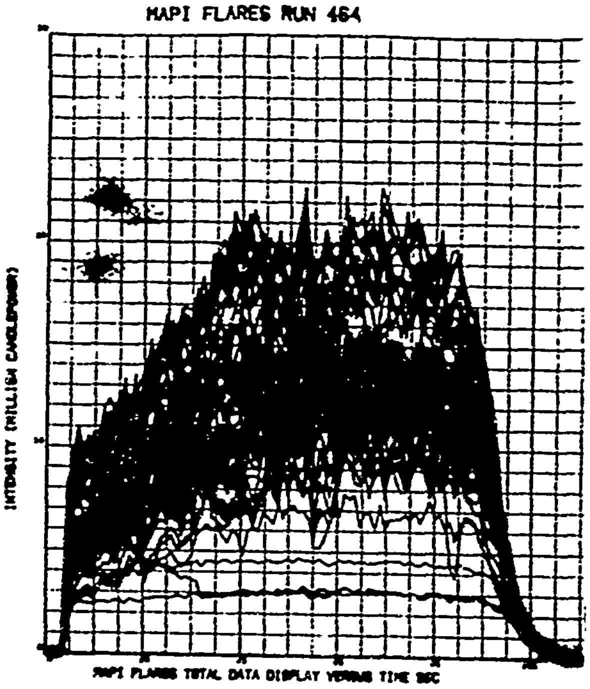
INSTANTANEOUS TIME, AVERAGE OF HIGH 29 PHOTOCELLS, INTEGRATED CANDLEPOWER SECONDS FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME 10, STANDARD DEVIATION OF HIGH 29 PHOTOCELLS, UNIFORMITY FACTOR

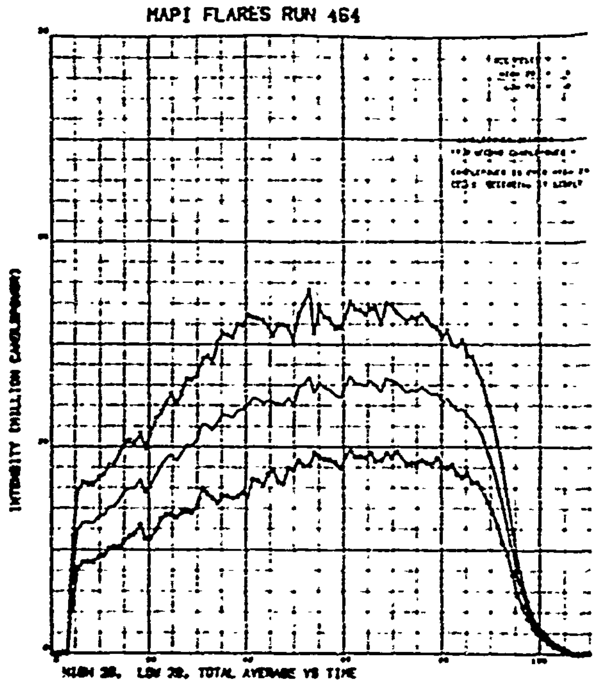
TIME (SEC)	HIGH 29 AVG	CP-SEC	AVG CP 0 SEC	AVG CP 10 SEC	STD DEV	U
.24	.03	.02	.02	.00	.01	1.69
1.28	.00	.02	.01	.00	.01	2.00
2.31	.00	.02	.01	.00	.00	-.00
3.34	.01	2.96	.71	.00	.01	2.00
4.39	5.41	10.00	1.92	.00	1.39	.82
5.44	7.80	18.48	2.95	.00	1.27	.62
6.50	8.25	27.19	3.72	.00	1.45	.62
7.55	8.21	35.89	4.29	.00	1.32	.60
8.61	8.21	44.78	4.74	.00	1.31	.60
9.68	8.50	53.91	5.13	.00	1.10	.58
10.74	8.68	63.42	5.48	8.87	1.22	.59
11.81	9.06	73.09	5.78	9.98	1.66	.57
12.87	9.12	83.05	6.06	9.13	1.65	.57
13.93	9.72	93.58	6.34	9.34	1.53	.62
14.99	10.23	104.51	6.61	9.52	1.52	.62
16.05	10.29	115.45	6.84	9.64	1.38	.58
17.12	10.18	126.61	7.05	9.75	1.40	.55
18.20	10.61	137.58	7.23	9.82	1.43	.53
19.26	9.93	148.57	7.39	9.87	1.71	.57
20.33	10.65	160.31	7.57	9.98	1.42	.63
21.40	11.33	172.56	7.76	10.12	2.03	.63
22.47	11.66	185.26	7.95	10.27	1.69	.57
23.53	12.15	198.39	8.14	10.43	2.19	.59
24.60	12.55	211.49	8.32	10.56	2.14	.61
25.66	12.12	224.68	8.48	10.68	2.14	.60
26.72	12.62	238.47	8.66	10.83	1.99	.69
27.79	15.32	252.60	8.83	10.97	2.15	.64
28.85	13.30	266.84	8.99	11.11	2.22	.65
29.91	13.55	281.62	9.15	11.26	1.89	.62
30.97	14.29	296.81	9.34	11.41	2.17	.57
32.03	14.43	311.82	9.49	11.55	2.27	.61
33.06	14.14	327.13	9.65	11.69	2.30	.62
34.13	15.09	343.25	9.82	11.84	2.84	.70
35.18	15.55	359.58	9.99	11.99	2.83	.69
36.23	15.49	375.86	10.15	12.13	2.99	.68
37.29	15.38	392.41	10.30	12.26	2.89	.69
38.34	16.03	409.23	10.45	12.40	3.50	.72
39.39	15.97	426.24	10.60	12.54	3.34	.69
40.44	16.44	443.35	10.75	12.67	2.90	.73
41.48	16.34	460.41	10.89	12.79	2.97	.64
42.53	16.29	477.36	11.02	12.90	3.09	.65
43.57	16.20	494.06	11.13	12.99	2.92	.66
44.61	15.69	510.41	11.24	13.07	2.54	.59
45.66	15.48	526.94	11.34	13.15	2.53	.54
46.71	15.99	543.69	11.44	13.23	2.98	.64
47.75	15.99	560.30	11.54	13.31	2.64	.65
48.80	15.85	576.54	11.62	13.37	2.33	.55
49.84	15.22	593.14	11.71	13.43	2.41	.52
50.89	16.48	610.70	11.81	13.51	2.20	.56
51.94	17.03	628.90	11.92	13.61	2.50	.61

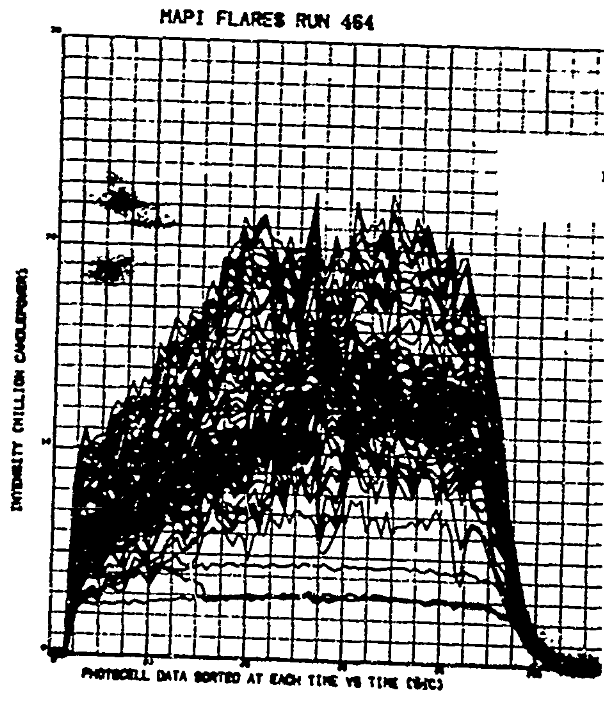
MAPI FLARES RUN 464

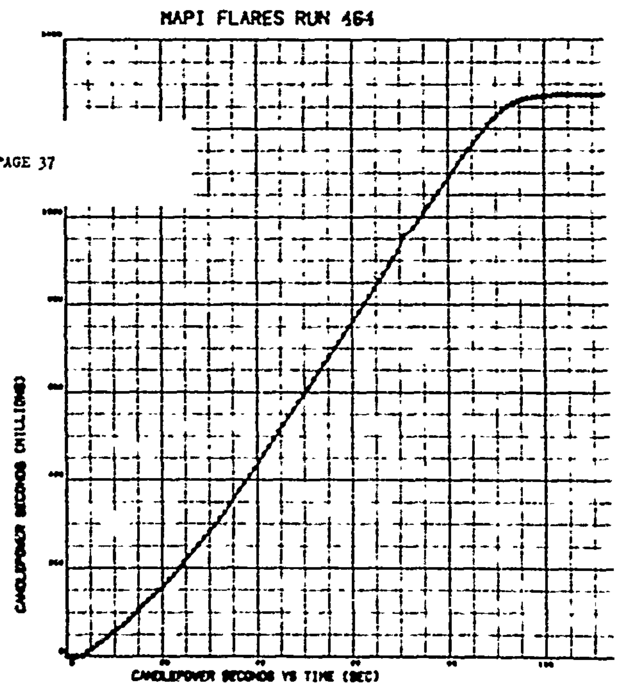
INSTANTANEOUS TIME, AVERAGE OF HIGH 29 PHOTOCELLS, INTEGRATED CANDLEPOWER SECONDS FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME 10, STANDARD DEVIATION OF HIGH 29 PHOTOCELLS,UNIFORMITY FACTOR

TIME (SEC)	HIGH 29 AVG	CP-SEC	AVG CP 0 SEC	AVG CP 10 SEC	STD DEV	U
51.94	17.03	628.90	11.92	13.61	2.50	.61
52.99	17.67	646.48	12.01	13.68	3.17	.64
54.04	15.59	663.50	12.09	13.74	1.87	.47
55.09	16.81	681.02	12.18	13.81	1.08	.55
56.15	16.38	698.35	12.26	13.87	1.52	.54
57.21	18.27	715.31	12.33	13.92	2.05	.54
58.27	15.81	731.98	12.39	13.96	1.92	.52
59.32	15.85	748.88	12.43	14.00	2.29	.56
60.37	16.35	766.35	12.53	14.06	2.40	.53
61.42	17.09	783.97	12.60	14.12	2.73	.54
62.48	16.73	801.34	12.67	14.17	2.75	.55
63.50	16.71	818.58	12.73	14.21	2.37	.55
64.54	16.52	835.92	12.79	14.26	2.38	.54
65.58	16.76	853.49	12.86	14.31	2.50	.53
66.63	16.90	870.68	12.91	14.35	2.65	.58
67.67	16.03	887.95	12.97	14.39	2.58	.53
68.72	17.07	905.62	13.03	14.43	3.12	.55
69.76	16.91	923.00	13.08	14.47	2.83	.56
70.80	16.56	956.39	13.18	14.53	2.58	.52
72.87	16.16	973.94	13.22	14.56	2.65	.55
73.92	16.36	990.93	13.26	14.59	2.81	.56
74.96	13.24	1007.95	13.30	14.62	2.67	.55
76.00	16.50	1024.97	13.35	14.65	3.03	.55
77.04	16.29	1041.77	13.38	14.67	2.58	.56
78.33	15.94	1058.27	13.42	14.69	2.45	.54
79.12	15.79	1074.39	13.44	14.70	2.23	.50
80.15	15.30	1090.39	13.47	14.71	2.53	.52
81.19	15.68	1106.28	13.49	14.72	2.89	.54
82.22	15.00	1121.79	13.51	14.73	1.91	.49
83.26	14.91	1137.33	13.53	14.73	2.26	.53
84.29	15.20	1152.63	13.55	14.73	2.43	.56
85.32	14.45	1167.46	13.56	14.73	2.11	.50
86.35	14.41	1181.82	13.56	14.72	1.69	.54
87.37	13.68	1195.66	13.56	14.70	1.56	.49
88.40	13.19	1208.62	13.55	14.67	2.04	.49
89.43	12.07	1220.71	13.53	14.64	1.79	.49
90.46	11.35	1231.82	13.50	14.59	1.26	.50
91.49	10.19	1241.71	13.45	14.52	1.35	.49
92.53	8.46	1250.10	13.39	14.44	1.11	.50
93.57	7.30	1256.89	13.32	14.34	.71	.42
94.61	5.84	1262.14	13.23	14.23	.40	.43
95.63	4.39	1266.07	13.13	14.11	.63	.44
96.65	3.35	1269.01	13.03	13.98	.34	.40
97.66	2.45	1271.17	12.91	13.84	.21	.36
98.69	1.79	1272.74	12.80	13.70	.15	.36
99.70	1.30	1273.94	12.68	13.56	.12	.32
100.71	1.04	1274.84	12.56	13.42	.09	.33
101.73	.73	1275.47	12.44	13.28	.08	.33
102.74	.53	1275.95	12.33	13.14	.04	.40
103.75	.42	1276.30	12.21	13.00	.03	.35
104.75	.27	1276.52	12.10	12.87	.03	.41
105.76	.16	1276.62	11.98	12.73	.03	.56
106.77	.04	1276.65	11.87	12.60	.02	1.95
107.80	.03	1276.68	11.76	12.47	.02	1.84
108.83	.02	1276.70	11.65	12.34	.01	2.00
109.86	.03	1276.73	11.54	12.21	.02	1.78
110.89	.03	1276.75	11.43	12.09	.02	2.00
111.91	.00	1276.76	11.33	11.96	.01	2.00
112.94	.01	1276.76	11.23	11.85	.01	2.00
113.98	.00	1276.76	11.12	11.73	.00	-.00
115.00	.00	.00	.00	.00	.00	-.00


MAPI FLARES RUN 464
INTENSITY (MILLION CANDLEPOWER)
MAPI FLARES TOTAL DATA DISPLAY VERSUS TIME SEC


MAPI FLARES RUN 464
INTENSITY (MILLION CANDLEPOWER)
HIGH 20, LOW 20, TOTAL AVERAGE VS TIME


MAPI FLARES RUN 464
INTENSITY (MILLION CANDLEPOWER)
PHOTOCELL DATA SORTED AT EACH TIME VS TIME (SEC)


MAPI FLARES RUN 464
CANDLEPOWER SECONDS (MILLIONS)
CANDLEPOWER SECONDS VS TIME (SEC)

NAFI FLARES RUN 556

INSTANTANEOUS TIME, AVERAGE OF HIGH 29 PHOTOCELLS, INTEGRATED CANDLEPOWER SECONDS FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME 10, STANDARD DEVIATION OF HIGH 29 PHOTOCELLS, UNIFORMITY FACTOR

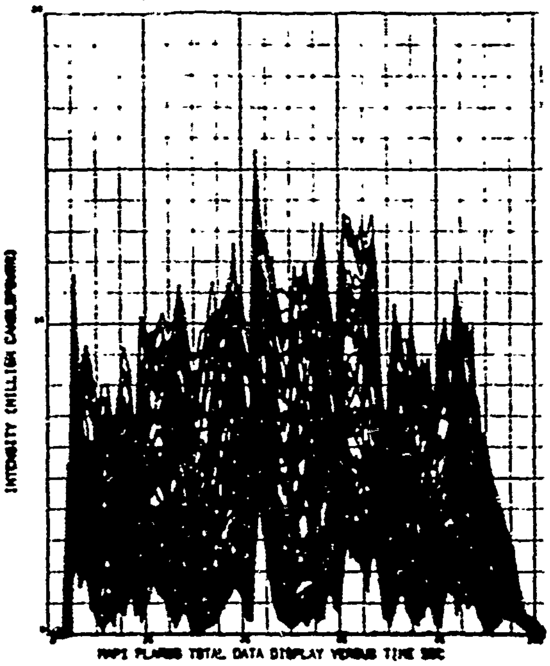
TIME (SEC)	HIGH 29 AVG	CP-SEC	AVG CP 0 SEC	AVG CP 10 SEC	STD DEV	U
.96	.05	.03	.02	.00	.03	2.00
2.10	.00	.06	.02	.00	.00	-.99
3.23	.05	1.67	.49	.00	.03	1.93
4.37	2.79	7.22	1.39	.00	1.25	1.44
5.51	6.93	14.75	2.59	.00	2.17	.74
6.65	5.30	21.77	3.19	.00	1.22	.84
7.78	6.10	28.26	3.55	.00	1.77	.86
8.91	5.58	34.13	3.76	.00	1.78	1.11
10.04	5.04	40.21	3.94	.00	1.33	1.12
11.17	5.71	46.72	4.12	.03	1.26	1.14
12.30	5.73	53.11	4.26	5.64	1.27	1.11
13.43	5.48	59.00	4.34	5.42	.84	1.13
14.56	4.95	65.22	4.43	5.45	1.56	1.06
15.70	6.08	72.12	4.54	5.61	1.83	1.21
16.83	6.09	77.32	4.55	5.46	1.53	.99
17.96	3.07	83.24	4.59	5.37	1.39	1.04
19.10	7.36	91.49	4.75	5.64	1.65	1.05
20.24	7.16	99.73	4.38	5.84	1.56	.98
21.37	7.73	108.07	5.01	6.01	1.51	.93
22.51	7.55	116.56	5.14	6.15	1.57	.99
23.65	7.54	124.57	5.23	6.21	1.61	1.05
24.79	6.57	132.28	5.30	6.22	1.33	1.17
25.93	7.01	140.82	5.34	6.37	1.76	1.27
27.07	8.06	149.42	5.49	6.46	2.01	1.16
28.20	7.17	156.66	5.52	6.45	2.02	1.17
29.34	5.56	162.97	5.52	5.39	1.90	1.43
30.48	5.47	169.55	5.53	6.36	2.02	1.45
31.61	6.07	176.50	5.55	6.35	2.00	1.42
32.77	6.23	184.74	5.53	6.36	2.30	1.45
33.91	7.21	192.71	5.65	6.42	2.17	1.22
35.05	7.63	201.54	[illegible]	6.44	1.95	1.29
36.18	7.90	215.92	5.96	5.56	2.02	1.17
37.32	8.55	220.78	[illegible]	6.66	1.92	1.07
38.47	8.72	229.95	5.35	6.71	2.02	1.31
39.61	7.33	237.71	5.39	6.71	2.15	1.08
40.74	6.34	244.82	5.94	6.70	2.10	1.23
41.88	6.18	254.69	6.16	6.77	1.84	1.25
43.00	11.45	266.42	6.17	6.96	1.93	.66
44.13	9.34	276.79	6.25	6.98	2.57	.74
45.26	9.60	286.62	6.31	7.04	2.23	1.00
46.39	8.37	295.50	6.35	7.06	2.25	1.12
47.53	7.24	303.49	6.36	7.06	2.29	1.28
48.67	6.87	311.38	6.37	7.06	2.24	1.32
49.80	7.04	320.05	6.40	7.07	2.25	1.41
50.95	8.09	329.13	6.44	7.10	2.30	1.27
52.08	7.36	338.35	6.47	7.13	2.29	1.25
53.22	2.26	347.41	6.51	7.15	2.28	1.22
54.36	7.68	356.11	6.53	7.16	2.28	1.22
55.49	7.63	365.81	6.57	7.20	2.51	1.29
56.63	9.43	375.27	6.61	7.23	2.55	1.19

NAFI FLARES RUN 558

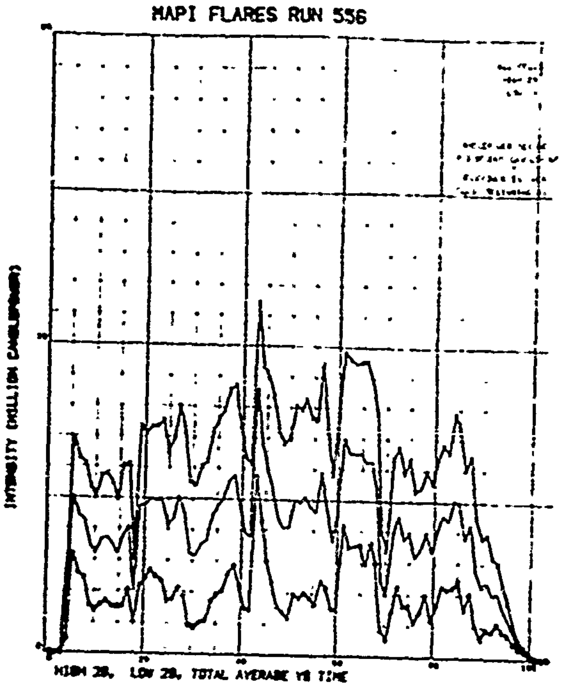
INSTANTANEOUS TIME, AVERAGE OF HIGH 29 PHOTOCELLS. INTEGRATED CANDLEPOWER SECONDS FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME ZERO, RUNNING MEAN CANDLEPOWER FROM TIME 10, STANDARD DEVIATION OF HIGH 29 PHOTOCELLS, UNIFORMITY FACTOR

TIME (SEC)	HIGH 29 AVG	CP-SEC	AVG CP 0 SEC	AVG CP 10 SEC	STD DEV	U
56.65	9.43	375.27	6.61	7.23	2.55	1.19
57.77	7.21	382.69	6.60	7.21	2.35	1.07
58.91	5.83	390.43	6.61	7.20	2.28	1.17
60.04	7.73	400.30	6.65	7.24	2.15	1.35
61.19	9.85	411.61	6.71	7.29	2.30	.81
62.33	9.60	422.47	6.76	7.34	2.37	.93
63.47	9.46	433.37	6.81	7.39	2.23	.91
64.61	9.51	444.27	6.86	7.43	2.23	.91
65.76	9.55	454.79	6.90	7.47	2.26	1.05
66.90	8.30	464.34	6.92	7.49	2.25	.94
68.04	7.95	471.08	6.91	7.46	1.94	.89
69.18	3.99	475.33	6.85	7.39	1.75	1.29
70.32	3.42	480.34	6.77	7.34	1.75	1.42
71.47	6.40	488.43	6.62	7.32	2.28	1.27
72.61	6.74	495.63	6.71	7.31	1.97	.9-
73.76	5.96	502.60	6.80	7.28	1.75	1.13
74.89	6.33	509.27	6.78	7.26	1.97	1.19
76.03	5.34	515.44	6.76	7.25	1.32	1.31
77.17	5.45	521.08	6.75	7.20	1.66	1.16
78.32	5.97	528.62	6.73	7.17	1.41	1.01
79.47	5.60	535.51	6.72	7.16	1.45	1.32
80.61	6.43	543.09	6.72	7.15	1.35	1.17
81.75	6.84	550.78	6.72	7.14	2.07	1.05
82.90	6.59	559.00	6.73	7.14	1.37	1.00
84.05	7.86	567.37	6.74	7.15	2.12	1.11
85.20	7.41	575.60	6.74	7.14	1.71	1.09
86.34	6.08	582.74	6.74	7.13	1.87	1.19
87.49	6.47	589.05	6.72	7.10	1.45	1.03
88.63	4.48	593.91	6.69	7.06	1.28	1.22
89.76	3.35	593.25	6.65	7.02	1.30	1.41
90.92	3.92	602.31	6.61	6.97	.91	1.71
92.06	3.22	605.90	6.57	6.91	.67	1.16
93.20	3.15	509.97	6.52	6.85	.52	.92
94.35	2.31	611.32	6.47	6.79	.51	.90
95.49	1.79	612.30	6.41	6.71	.45	.85
96.54	1.06	613.35	6.34	6.63	.23	.71
97.79	.55	614.41	6.27	6.55	.08	.55
98.93	.37	614.71	6.20	6.47	.06	.44
100.08	.15	614.85	6.13	6.39	.03	.88
101.23	.08	614.91	6.06	6.31	.03	1.56
102.38	.02	614.95	6.00	6.23	.02	2.00
103.52	.05	.96	.06	.00	.02	1.72

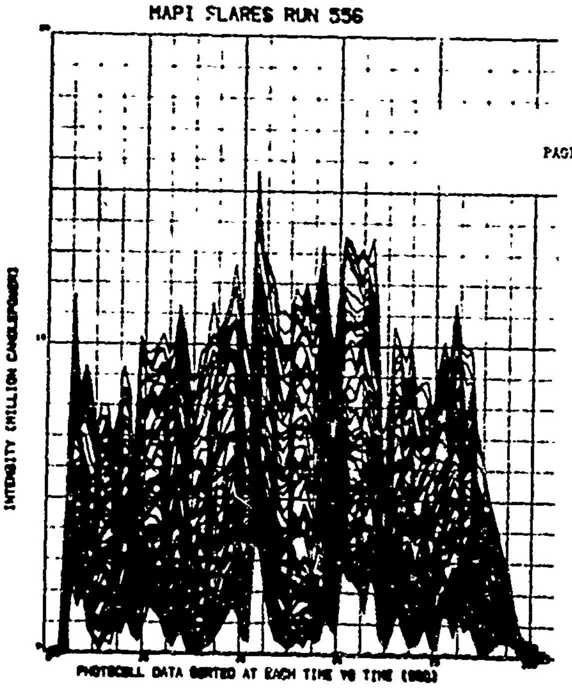
MAPI FLARES RUN 556



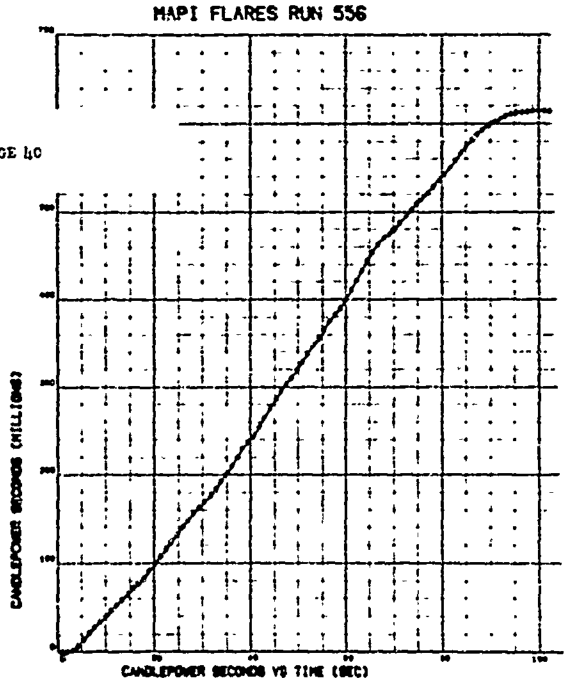
MAPI FLARES RUN 556



MAPI FLARES RUN 556



MAPI FLARES RUN 556



APPENDIX IV

DIAMETER STUDY

Summary Sheets for Pressed Candles
and Hybrid Series

EPOXY HYBRID CANDLES

12 September 1967

MAPI Test No.	611	616	621	641	642	643	644
Magnesium % (gran 18)	58.5	58.5	58.5	58.5	58.5	58.5	58.5
Sodium Nitrate %	37.5	37.5	37.5	37.5	37.5	37.5	37.5
Binder* %	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Luminous intensity ($x10^6$cd)	2.99	3.41	3.03	3.24	3.26	2.94	2.98
Burning time (sec)	183	159	185	170	171	185	165
Efficiency ($x10^3$cd-sec/g)	40.1	39.8	41.4	40.5	40.9	36.5	36.2
Composition diameter (in)	7.35	7.35	7.35	7.35	7.35	7.35	7.35
Composition weight (lb)	30	30	30	30	30	33	30
Pressing pressure (psi)	2830	2830	2830	2830	2830	2830	2830
Burning rate (in/sec)	0.06	0.07	0.06	0.07	0.07	0.075	0.08
Density (g/cm^3)	1.65	1.65	1.62	1.77	1.77	1.56	1.48
Burning rate (g/sec)	74.4	85.7	73.5	80.5	79.9	80.9	82.5
Composition length (in)	11.8	11.9	12.1	12.1	12.1	13.7	13.2

* Epoxy binder formula: 70% DER 321 plus 30% DER 732 plus 11 phr DER 24.

EPOXY HYBRID CANDLES

12 September 1967

MAPI Test No.	609	614	619	640	610	615	620	622
Magnesium % (gran 18)	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5
Sodium Nitrate %	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5
Binder* %	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Luminous intensity ($x10^6$cd)	0.48	0.45	0.42	0.46	1.10	1.27	1.15	1.24
Burning time (sec)	195	~215	226	~214	187	185	185	190
Efficiency ($x10^3$cd-sec/g)	48	49.7	48.1	52.3	42.2	48.2	43.5	48.1
Composition diameter (in)	2.66	2.66	2.66	2.66	4.25	4.25	4.25	4.25
Composition weight (lb)	4.3	4.3	4.3	4.3	10.8	10.8	10.8	10.8
Pressing pressure (psi)	2830	2830	2830	2830	2830	2830	2830	2830
Burning rate (in/sec)	0.06	0.06	0.06	0.05	.072	0.07	0.07	0.07
Density (g/cm^3)	1.63	1.59	1.58	1.57	1.56	1.57	1.56	1.56
Burning rate (g/sec)	9.9	9.1	8.63	9.1	26.2	26.5	26.5	25.8
Composition length (in)	13.4	13.5	13.6	13.5	13.5	13.4	13.5	13.5

* Epoxy binder formula: [illegible]0% DER 321 plus 30% DER 732 plus 11 phr DER 24.

DIAMETER STUDY: PRESSED CANDLES (by Formula) 22 September 1967

Test No.	Formula*	Diameter (in)	Density (g/cm^3)	Burning Rate-sec/in	Luminous Intensity ($x10^3$ cd)	Efficiency ($x10^3 \frac{cd\text{-}sec}{g}$)	Surface Area Output ($x10^3 cd/in^2$)
T-499	55/40/5	1.76	1.75	15.3	1.61	35.4	66
T-2624	55/40/5	1.76	1.80	15.7	1.64	30.9	67
T-3375	55/40/5	1.76	1.85	16.1	1.60	35.0	65
T-502	55/40/5	1.76	1.75	15.3	1.41	31.0	59
T-2625	55/40/5	1.76	1.78	15.3	1.55	33.3	63
T-3376	55/40/5	1.76	1.83	15.2	1.66	34.5	68
T-3377	55/40/5	1.76	1.85	15.3	1.66	34.4	68
T-3378	55/40/5	1.76	1.87	14.5	1.84	35.8	75
MAPI 484	55/40/5	2.66	1.80	15.3	3.20	29.8	57
MAPI 538	55/40/5	2.66	1.75	14.2	3.90	34.9	70
MAPI 493	55/40/5	2.66	1.82	15.3	3.20	29.6	57
MAPI 547	55/40/5	2.66	1.76	14.7	3.60	32.8	64

* 55% granulation 18 magnesium, 40% 30-micron sodium nitrate, and 5% Laminac 4116 binder.

DIAMETER STUDY: PRESSED CANDLES (by Formula) 22 September 1967

MAPI No.	Formula*	Diameter (in)	Density (g/cm^3)	Burning Rate-sec/in	Luminous Intensity ($x10^3$cd)	Efficiency ($x10^3$cd-sec/g)	Surface Area Output ($x10^3 cd/in^2$)
485	55/40/5	4.25	1.82	14.8	12.0	42.2	84
539	55/40/5	4.25	1.61	13.2	13.4	48.7	94
494	55/40/5	4.25	1.89	14.7	12.4	41.7	87
548	55/40/5	4.25	1.58	13.4	14.1	51.9	99
486	55/40/5	7.35	1.90	14.9	37.1	42.1	87
540	55/40/5	7.35	1.79	12.4	37.1	37.2	87
495	55/40/5	7.35	1.90	15.0	36.9	42.2	87
549	55/40/5	7.35	1.76	12.5	39.3	40.0	92

* 55% granulation 18 magnesium, 40% 30-micron sodium nitrate, and 5% Laminac 4116 binder.

DIAMETER STUDY: PRESSED CANDLES (by Formula) 22 September 1967

Test No.	Formula*	Diameter (in)	Density (g/cm^3)	Burning Rate-sec/in	Luminous Intensity ($x10^5$cd)	Efficiency ($x10^3$cd-sec / g)	Surface Area Output ($x10^3cd/in^2$)
T-500	62/33/5	1.76	1.74	10.6	2.67	40.9	109
T-2626	62/33/5	1.76	1.76	12.1	2.57	43.3	105
T-3379	62/33/5	1.76	1.83	10.0	2.98	40.7	122
T-503	62/33/5	1.76	1.72	9.8	2.75	39.6	113
T-2627	62/33/5	1.76	1.76	11.2	2.57	41.1	105
T-3380	62/33/5	1.76	1.83	9.3	3.27	41.7	134
T-3381	62/33/5	1.76	1.83	9.4	3.15	40.7	129
T-3382	62/33/5	1.76	1.83	8.8	3.27	39.8	134
MAPI 487	62/33/5	2.66	1.77	11.0	5.10	35.1	91
MAPI 541	62/33/5	2.66	1.73	11.3	6.20	44.3	112
MAPI 496	62/33/5	2.66	1.71	11.2	4.70	32.9	84
MAPI 550	62/33/5	2.66	1.73	11.8	5.50	41.1	99

* 62% granulation 18 magnesium, 33% 30-micron sodium nitrate, and 5% Laminac 4116 binder.

DIAMETER STUDY: PRESSED CANDLES (by Formula) 27 September 1967

Test No.	Formula*	Diameter (in.)	Density (g/cm^3)	Burning Rate-sec/in	Luminous Intensity ($x10^5$ cd)	Efficiency ($x10^3$ $\frac{cd\text{-}sec}{g}$)	Surface Area Output ($x10^3$ cd/in^2)
623	55/40/5	2.66	1.80	15.1	4.4	41.1	79
624	55/40/5	2.66	1.74	15.1	4.4	42.0	79
625	55/40/5	2.66	1.80	15.1	4.7	43.0	84
626	55/40/5	2.66	1.80	15.3	4.4	41.1	79
645	55/40/5	2.66	1.80	14.4	4.7	41.7	84
646	55/40/5	2.66	1.80	14.3	4.6	40.5	82
647	55/40/5	2.66	1.80	14.8	4.7	41.7	84
648	55/40/5	2.66	1.80	14.7	4.2	37.9	75

* 55% granulation 18 magnesium, 40% 30-micron sodium nitrate, and 5% Laminac 4116 binder.

DIAMETER STUDY: PRESSED CANDLES: (by Formula) 27 September 1967

Test No.	Formula*	Diameter (in)	Density (g/cm^3)	Burning Rate-sec/in	Luminous Intensity ($x10^5$ cd)	Efficiency ($x10^3 \frac{cd\text{-}sec}{g}$)	Surface Area Output ($x10^3$ cd/in^2)
T11838	55/40/5	2.66	1.79	13.8	6.2	53.1	114
T11839	55/40/5	2.66	1.79	13.4	6.2	51.3	113
T11840	55/40/5	2.66	1.79	13.7	5.9	49.9	107
T11841	55/40/5	2.66	1.79	13.7	6.0	51.3	110
T11842	55/40/5	2.66	1.79	13.8	5.8	49.3	105
T11843	55/40/5	2.66	1.79	13.4	6.2	51.3	113
T11844	55/40/5	2.66	1.79	13.4	6.1	50.3	110
T11845	55/40/5	2.66	1.79	13.9	6.0	51.3	109
T11846	55/40/5	2.66	1.79	13.8	5.9	50.8	108
T11847	55/40/5	2.66	1.79	13.7	6.1	51.3	112
T11848	55/40/5	2.66	1.79	13.7	6.0	51.3	110
T11849	55/40/5	2.66	1.79	13.8	6.1	52.1	111
T11850	55/40/5	2.66	1.79	13.8	6.0	51.6	110

* 55% granulation 18 magnesium, 40% 30-micron sodium nitrate, and 5% Laminac 4116 binder.

DIAMETER STUDY: PRESSED CANDLES (by Formula) 22 September 1967

MAPI No.	Formula*	Diameter (in)	Density (g/cm^3)	Burning Rate-sec/in	Luminous Intensity ($x10^5$ cd)	Efficiency ($\frac{x10^3 cd\text{-}sec}{g}$)	Surface Area Output ($x10^3 cd/in^2$)
488	62/33/5	4.25	1.80	11.7	14.9	41.7	105
542	62/33/5	4.35	1.54	8.8	18.4	46.1	130
497	62/33/5	4.25	1.80	10.4	15.8	39.3	111
551	62/33/5	4.25	1.54	9.6	18.7	50.8	132
489	62/33/5	7.35	1.63	8.5	47.8	35.9	112
543	62/33/5	7.35	1.76	8.9	50.5	37.1	119
498	62/33/5	7.35	1.63	8.6	47.5	36.0	112
552	62/33/5	7.35	1.75	9.3	49.6	38.1	117

* 62% granulation 18 magnesium 33% 30-micron sodium nitrate, and 5% Laminac 4116 binder.

DIAMETER STUDY: PRESSED CANDLES (by Formula) 22 September 1967

Test No.	Formula*	Diameter (in)	Density (g/cm^3)	Burning Rate-sec/in	Luminous Intensity ($x10^5$cd)	Efficiency ($x10^3$cd-sec / g)	Surface Area Output ($x10^3cd/in^2$)
T-501	70/25/5	1.76	1.68	9.9	2.75	40.8	113
T-2628	70/25/5	1.76	1.69	13.5	1.97	39.5	81
T-3383	70/25/5	1.76	1.75	9.4	2.73	36.8	112
T-504	70/25/5	1.76	1.66	9.7	2.84	42.0	116
T-2629	70/25/5	1.76	1.69	12.5	2.07	38.4	85
T-3384	70/25/5	1.76	1.75	9.3	2.76	36.8	113
T-3385	70/25/5	1.76	1.75	9.3	2.94	39.1	120
T-3386	70/25/5	1.76	1.75	9.0	3.12	40.3	12[illegible]
MAPI 490	70/25/5	2.66	1.72	8.6	6.00	33.1	108
MAPI 544	70/25/5	2.66	1.76	7.6	8.80	42.0	159
MAPI 499	70/25/5	2.66	1.71	8.3	5.80	30.8	104
MAPI 553	70/25/5	2.66	1.76	7.7	7.90	38.4	142

* 70% granulation 18 magnesium, 25% 30-micron sodium nitrate, and 5% Laminac 4116 binder.

DIAMETER STUDY: PRESSED CANDLES (by Formula) 22 September 1967

MAPI No.	Formula*	Diameter (in)	Density (g/cm^3)	Burning Rate-sec/in	Luminous Intensity ($x10^5 cd$)	Efficiency ($x10^3 \frac{cd\text{-}sec}{g}$)	Surface Area Output ($x10^3 cd/in^2$)
491	70/25/5	4.25	1.76	7.7	18.3	34.6	129
545	70/25/5	4.25	1.52	5.5	23.8	38.3	168
500	70/25/5	4.25	1.30	8.6	16.9	34.9	119
554	70/25/5	4.25	1.60	6.1	23.9	39.6	169
492	70/25/5	7.35	1.61	7.3	45.5	32.0	107
546	70/25/5	7.35	1.71	7.1	58.1	35.3	137
501	70/25/5	7.35	1.61	7.4	47.2	31.5	112
555	70/25/5	7.35	1.69	7.0	53.1	32.2	125

* 70% granulation 18 magnesium, 25% 30-micron sodium nitrate, and 5% Laminac 4116 binder.

DIAMETER STUDY: PRESSED CANDLES (by Diameter) 22 September 1967

Test No.	Formula	Diameter (in)	Density (g/cm^3)	Burning Rate-sec/in	Luminous Intensity ($x10^3$cd)	Efficiency ($x10^3 \frac{cd\text{-}sec}{g}$)	Surface Area Output ($x10^3 cd/in^2$)
T-499	55/40/5	1.76	1.75	15.3	1.61	35.4	66
T-2624	55/40/5	1.76	1.80	15.7	1.64	39.9	67
T-3375	55/40/5	1.76	1.85	16.1	1.60	35.0	65
T-502	55/40/5	1.76	1.75	15.3	1.41	31.0	58
T-2625	55/40/5	1.76	1.78	15.3	1.55	33.3	63
T-3376	55/40/5	1.76	1.83	15.2	1.66	34.5	68
T-3377	55/40/5	1.76	1.85	15.3	1.66	34.4	68
T-3378	55/40/5	1.76	1.87	14.5	1.84	35.8	75
T-500	62/33/5	1.76	1.74	10.6	2.67	40.9	109
T-2626	62/33/5	1.76	1.76	12.1	2.57	43.3	105
T-3379	62/33/5	1.76	1.83	10.0	2.98	40.7	122
T-503	62/33/5	1.76	1.72	9.8	2.75	39.6	113

DIAMETER STUDY: PRESSED CANDLES (by Diameter) 22 September 1967

Test No.	Formula	Diameter (in)	Density (g/cm^3)	Burning Rate-sec/in	Luminous Intensity ($x10^5$ cd)	Efficiency ($x10^3 \frac{cd\text{-}sec}{g}$)	Surface Area Output ($x10^3 cd/in^2$)
T-2627	62/33/5	1.76	1.76	11.2	2.57	41.1	105
T-3380	62/33/5	1.76	1.83	9.3	3.27	41.7	134
T-3381	62/33/5	1.76	1.83	9.4	3.15	40.7	129
T-3382	62/33/5	1.76	1.83	8.8	3.27	39.8	134
T-501	70/25/5	1.76	1.68	[illegible].9	2.75	40.8	113
T-2628	70/25/5	1.76	1.69	13.5	1.97	39.5	81
T-3383	70/25/5	1.76	1.75	9.4	2.73	36.8	112
T-504	70/25/5	1.76	1.66	9.7	2.84	42.0	116
T-2629	70/25/5	1.76	1.69	12.5	2.07	38.4	85
T-3384	70/25/5	1.76	1.75	9.3	2.76	36.8	113
T-3385	70/25/5	1.76	1.75	9.3	2.94	39.1	120
T-3386	70/25/5	1.76	1.75	9.0	3.12	40.3	128

DIAMETER STUDY: PRESSED CANDLES (by Diameter) 22 September 1967

MAPI No.	Formula	Diameter (in)	Density (g/cm^3)	Burning Rate-sec/in	Luminous Intensity ($x10^5$ cd)	Efficiency ($x10^3 \frac{cd\text{-}sec}{g}$)	Surface Area Output ($x10^3 cd/in^2$)
484	55/40/5	2.66	1.80	15.3	3.20	29.8	57
538	55/40/5	2.66	1.75	14.2	3.90	34.9	70
493	55/40/5	2.66	1.82	15.3	3.20	29.6	57
547	55/40/5	2.66	1.76	14.7	3.60	32.8	64
487	62/33/5	2.66	1.77	11.0	5.10	35.1	91
541	62/33/5	2.66	1.73	11.3	6.20	44.3	112
496	62/33/5	2.66	1.71	11.2	4.70	32.9	84
550	62/33/5	2.66	1.73	11.8	5.50	41.1	99
490	70/25/5	2.66	1.72	8.6	6.00	33.1	108
544	70/25/5	2.66	1.76	7.6	8.80	42.0	159
499	70/25/5	2.66	1.71	8.3	5.80	30.8	104
553	70/25/5	2.66	1.76	7.7	7.90	38.4	142

DIAMETER STUDY: PRESSED CANDLES (by Diameter) 22 September 1967

MAPI No.	Formula	Diameter (in)	Density (g/cm^3)	Burning Rate-sec/in	Luminous Intensity ($x10^3$cd)	Efficiency ($x10^3$ cd-sec/g)	Surface Area Output ($x10^3 cd/in^2$)
485	55/40/5	4.25	1.82	14.8	12.0	42.2	84
539	55/40/5	4.25	1.58	13.2	13.4	48.7	94
494	55/40/5	4.25	1.89	14.7	12.4	41.7	87
548	55/40/5	4.25	1.58	13.4	14.1	51.9	99
488	62/33/5	4.25	1.80	11.7	14.9	41.7	105
542	62/33/5	4.25	1.54	8.8	18.4	46.1	130
497	62/33/5	4.25	1.80	10.4	15.8	39.3	111
551	62/33/5	4.25	1.54	9.6	18.7	50.8	132
491	70/25/5	4.25	1.76	7.7	18.3	34.6	129
545	70/25/5	4.25	1.52	5.5	23.8	38.3	168
500	70/25/5	4.25	1.80	8.6	16.9	34.9	119
554	70/25/5	4.25	1.61	6.1	23.9	39.6	169

DIAMETER STUDY: PRESSED CANDLES (by Diameter) 22 September 1967

MAPI No.	Formula	Diameter (in)	Density (g/cm^3)	Burning Rate-sec/in	Luminous Intensity ($x10^5$ cd)	Efficiency ($x10^3 \frac{cd\text{-}sec}{g}$)	Surface Area Output ($x10^3 cd/in^2$)
486	55/40/5	7.35	1.90	14.9	37.1	42.1	87
540	55/40/5	7.35	1.79	12.4	37.1	37.2	87
495	55/40/5	7.35	1.90	15.0	36.9	42.2	87
549	55/40/5	7.35	1.76	12.5	39.3	40.0	92
489	62/33/5	7.35	1.63	8.5	47.8	35.9	112
543	62/33/5	7.35	1.76	8.9	50.5	37.1	119
498	62/33/5	7.35	1.63	8.6	47.5	36.0	112
552	62/33/5	7.35	1.75	9.3	49.6	38.1	117
492	70/25/5	7.35	1.61	7.8	45.5	32.0	107
546	70/25/5	7.35	1.71	7.1	58.1	35.3	137
501	70/25/5	7.35	1.61	7.4	47.2	31.5	112
555	70/25/5	7.35	1.69	7.0	53.1	32.2	125

APPENDIX V

DIAMETER STUDY

Summary Sheets for Cast Candles
from 4.25 inch diameter thru 24 inch diameter

4.25" DIAMETER SOLID CAST FLARES — 12 September 1967

MAPI Test No.	506	521	589	590	649	650	651
Magnesium %	54.4	54.4	61.0	61.0	58.0	58.0	58.0
(granulation)	(15)	(15)	(15)	(15)	(15)	(15)	(15)
Sodium Nitrate %	31.2	31.2	30.0	30.0	30.0	30.0	30.0
(particle size)	(150μ)	(150μ)	(30μ)	(30μ)			
Binder* %							
Silicone	14.4	14.4					
Epoxy-Polyglycol			2.0	2.0			
Polysulfide			7.0	7.0			
					12.0	12.0	12.0
Luminous Intensity ($x10^6$cd)	0.9	~1.0	0.9	~1.1	3.5	2.8	2.8
Burning Time (sec)	94	~90	121	~126	24	31	28
Efficiency ($x10^3$ $\frac{cd\text{-}sec}{g}$)	21.4	~23.4	35.1	~30.8	22.3	23.9	22.2
Burning Rate (in/sec)	0.14	~0.15	0.09	~0.09	0.46	0.35	0.38
Burning Rate (sec/in)	6.7	~6.55	10.3	~10.9	2.1	2.8	2.8
Burning Rate (g/sec)	43.2	~40.9	30.1	~26.1	~157	117	127
Density (g/cm^3)	1.26	~1.28	1.32	~1.34	~1.43	1.45	1.43
Composition Weight ($x10^3$)	4.0	4.0	3.6	3.6	3.8	3.7	3.6

* Silicone formula: Sylgard 182 mix plus curing agent.
Epoxy-Polyglycol formula: 62% QX 3812, and 38% DER 782.
Polysulfide formula: 11.2 parts Thiokol LP-2 plus 0.8 parts PbO_2.

4.25" DIAMETER SOLID CAST FLARES

12 September 1967

MAPI Test No.	578	585	586	579	587	588
Magnesium %	60.0	60.0	60.0	61.0	61.0	61.0
(granulation)	(15)	(15)	(15)	(15)	(15)	(15)
Sodium Nitrate %	30.0	30.0	30.0	30.0	30.0	30.0
(particle size)	(30μ)	(30μ)	(30μ)	(30μ)	(30μ)	(30μ)
Binder* %						
Polyester	10.0	10.0	10.0			
Epoxy				9.0	9.0	9.0
Luminous Intensity ($\times 10^6$ cd)	1.4	1.2	1.2	1.0	0.8	1.0
Burning Time (sec)	76	72	66	110	116	111
Efficiency ($\times 10^3$ $\frac{\text{cd-sec}}{\text{g}}$)	33.7	26.7	26.4	31.4	28.4	30.6
Burning Rate (in/sec)	0.15	0.16	0.17	0.10	0.09	0.10
Burning Rate (sec/in)	6.4	6.1	5.7	9.7	10.0	9.6
Burning Rate (g/sec)	'4.4	46.3	49.5	31.9	30.8	31.6
Density (g/cm^3)	1.26	1.24	1.23	1.34	1.33	1.31
Composition Weight ($\times 10^3$ g)	3.3	3.3	3.3	3.5	3.6	3.5

* Polyester formula: 98.5% Laminac 4116 and 1.5% Lupersol DDM.
Epoxy formula: 30% DER 732, 70% DEH 325 and 11 phr DEH 24.

7.35" SOLID CAST FLARES 12 September 1967

MAPI Test No.	465	505	469	470
Magnesium %	54.4	54.4	56.0	56.0
(granulation)	(15)	(15)	(17)	(17)
Sodium Nitrate %	31.2	31.2	28.0	26.0
(particle size)	(150μ)	(150μ)	(150μ)	(150μ)
Aluminum Chaff (.002 x .008 x $\frac{1}{4}$)			1.0	3.0
Binder* %				
Silicone	14.4	14.4		
Epoxy-Polyglycol			15.0	15.0
Luminous Intensity ($x10^6$cd)	2.6	2.5	~1.0	~1.0
Burning Time (sec)	97	88	~175	~165
Efficiency ($x10^3 \frac{cd\text{-}sec}{g}$)	18.5	19.1	~12.8	~12.1
Burning Rate (in/sec)	0.16	0.15	~0.08	~0.08
Burning Rate (sec/in)	6.0	6.4	~12.5	~11.8
Burning Rate (g/sec)	144	133	~77.9	~82.7
Density (g/cm^3)	1.25	1.23	~1.36	~1.36
Composition Weight ($x10^3$g)	14.0	11.8	13.6	13.6

* Silicone formula: Sylgard 182 mix plus curing agent.
Epoxy-Polyglycol formula: 62% QX 3812 and 38% DER 732.

8.0" DIAMETER SOLID CAST FLARES 12 September 1967

MAPI Test No.	577	584	576	583	652	653
Magnesium % (granulation)	61.0 (15)	61.0 (15)	60.0 (15)	60.0 (15)	58.0 (15)	58.0 (15)
Sodium Nitrate % (particle size)	30.0 (30µ)	30.0 (30µ)	30.0 (30µ)	30.0 (30µ)	30.0	30.0
Binder* %						
Polyester			10.0	10.0		
Epoxy	9.0	9.0				
Polysulfide					12.0	12.0
Luminous Intensity ($x10^6$cd)	1.5	1.3	1.6	1.3	2.8	2.4
Burning Time (sec)	77	78	64	65	65	68
Efficiency ($x10^3 \frac{cd\text{-}sec}{g}$)	13.1	11.5	11.6	9.8	20.3	18.5
Burning Rate (in/sec)	0.10	0.10	0.13	0.13	0.12	.11
Burning Rate (sec/in)	9.2	9.4	7.3	7.4	7.2	8.5
Burning Rate (g/sec)	117	114	141	139	139	132
Density (g/cm^3)	1.31	1.31	1.26	1.26	2.76	1.37
Composition Weight ($x10^3$g)	9.0	9.0	9.0	9.0	9.0	9.0

* Polyester formula: 98.5% Laminac 4116 and 1.5% Lupersol DDM.
Epoxy formula: 30% DER 732. 70% DER 321 and 11 phr DEH 24.
Polysulfide formula: 11.2 parts Thiokol LP-2 plus 0.8 parts PbO_2.

12.0" DIAMETER SOLID CAST FLARES

12 September 1967

MAPI Test No.	507	466	504	523	605	606
Magnesium %	56.0	54.4	54.4	54.4	61.0	61.0
(granulation)	(15)	(15)	(15)	(15)	(15)	(15)
Sodium Nitrate %	31.2	31.2	31.2	31.2	30.0	30.0
(particle size)	(150µ)	(150µ)	(150µ)	(150µ)		
Binder* %						
Silicone	12.8	14.4	14.4	14.4		
Epoxy					9.0	9.0
Luminous Intensity ($x10^6$cd)	7.3	4.0	6.0	5.9	1.3	~1.4
Burning Time (sec)	64	46	83	85	84	84
Efficiency ($x10^3$, $\frac{cd\text{-}sec}{g}$)	14.9		15.9	16.0	5.5	~6.1
Burning Rate (in/sec)	0.20	0.28	0.15	0.15	~0.10	~0.10
Burning Rate (sec/in)	4.88		6.4	~6.54	9.9	9.9
Burning Rate (g/sec)	493		382	~374	240	242
Density (g/cm^3)	1.29		1.28	~1.32	1.30	1.30
Composition Weight ($x10^3$g)	31.8	31.3	31.8	31.8	20.4	20.4

*Silicone formula: Sylgard 182 mix.
Epoxy formula: 30% DER 732, 70% DER 321 and 11 phr DEH 24.

16.0" DIAMETER SOLID CAST FLARES　　　　12 September 1967

MAPI Test No.	203	299	370	371	393	424	467
Magnesium %	60.0	57.0	58.4	58.4	56.0	56.0	54.4
(granulation)	(17)	(17)	(15)	(17)	(15)	(15)	(15)
Sodium Nitrate %	25.0	29.2	28.8	28.8	31.2	31.2	31.2
(particle size)	(30μ)	(150μ)	(150μ)	(150μ)	(150μ)	(150μ)	(150μ)
Binder* %							
Silicone	15.0	13.8	12.8	12.8	12.8	12.8**	14.4
Luminous Intensity ($x10^6$cd)	4.7	3.7	4.2	2.5	9.0	7.7	8.3
Burning Time (sec)	123	160	81	65	72	43	81
Efficiency ($x10^3 \frac{cd\text{-}sec}{g}$)	10.4	10.7	6.5		11.1	11.8	11.9
Burning Rate (in/sec)	0.10	0.08	0.14	0.24	0.18	0.14	0.14
Burning Rate (sec/in)	9.5	12.4	6.6		5.3	7.0	6.7
Burning Rate (g/sec)	460	351	568		782	658	700
Density (g/cm^3)	1.33	1.33	1.33	1.41	1.28	1.38	1.44
Composition Weight ($x10^3$g)	56.7	56.7	56.7	56.7	56.7	28.4	56.7

* Silicone formula: Sylgard 182 mix or ** RTV 615.

16.0" DIAMETER SOLID CAST FLARES 12 September 1967

MAPI Test No.	383	392	421	419	422	423	574	575
Magnesium %	56.0	56.0	56.0	36.0	29.0	23.0	60.0	61.0
(granulation)	(15)	(15)	(17)	(17)	(15)	(15)	(15)	(15)
Sodium Nitrate %	31.2	31.2	28.0	48.0			30.0	30.0
(particle size)	(150μ)	(150μ)	(150μ)	(150μ)			(150μ)	(150μ)
Barium Nitrate %					55.0	53.0		
Dechlorane						8.0		
Binder* %								
Polyester							10.0	
Epoxy								9.0
Epoxy-Polyglycol	12.8	12.8						
Polysulfide			16.0	16.0	16.0	16.0		
Luminous Intensity ($x10^6$cd)	0.9	0.8	2.4	3.3	1.1	0.8	4.4	2.3
Burning Time (sec)	242	250	88	83	49	66	47	61
Efficiency ($x10^3 \frac{cd\text{-}sec}{g}$)	4.2	3.5	8.1	10.3	2.0	2.1	7.7	5.3
Burning Rate (in/sec)	0.06	0.05	0.06	0.06	0.08	0.05	0.13	0.10
Burning Rate (sec/in)	15.2	19.8	15.4	15.2	11.6	18.9	7.7	9.7
Burning Rate (g/sec)	242	227	307	272	547	439	573	444
Density (g/cm^3)	1.32	1.37	1.44	1.50	1.94	1.64	1.25	1.32
Composition Weight ($x10^3$g)	56.7	56.7	27.2	27.2	27.2	27.2	27.2	27.2

* Polyester formula: 98.5% Laminac 4116 and 1.5% Lupersol DDM.
Epoxy formula: 30% DER 732, 70% DER 321 and 11 phr DEH 24.
Epoxy-Polyglycol formula: 62% QX 3812 and 38% DER 732.
Polysulfide formula: 14.9 parts Thiokol LP-2 and 1.1 parts PbO_2.

20.0" DIAMETER SOLID CAST FLARES 12 September 1967

MAPI Test No.	503	604
Magnesium %	54.4	61.4
(granulation)	(15)	(15)
Sodium Nitrate %	31.2	30.0
(particle size)	(150 μ)	
Binder* %		
Silicone	14.4	
Epoxy		9.0
Luminous Intensity ($x10^6$cd)	12.9	5.95
Burning Time (sec)	47	~75
Efficiency ($x10^3 \frac{cd\text{-}sec}{g}$)	10.9	8.1
Burning Rate (in/sec)	0.16	~0.11
Burning Rate (sec/in)	5.9	8.8
Burning Rate ($x10^3$g/sec)	1.19	~1.56
Density (g/cm^3)	1.38	1.28
Composition Weight ($x10^3$g)	56.7	56.7

* Silicone formula: Sylgard 182 mix.
Epoxy formula: 30% DER 732, 70% DER 321 and 11 phr DEH 24.

24.0" DIAMETER SOLID CAST FLARES

12 September 1967

MAFI Test No.	502	603
Magnesium %	54.4	61.0
(granulation)	(15)	(15)
Sodium Nitrate %	31.2	30.0
(particle size)	(150 µ)	
Binder* %		
Silicone	14.4	
Epoxy		9.0
Luminous Intensity ($x10^6$cd)	16.3	~5.0
Burning Time (sec)	34	56
Efficiency ($x10^3$ $\frac{cd\text{-}sec}{g}$)	9.8	~4.9
Burning Rate (in/sec)	0.16	~0.11
Burning Rate (sec/in)	6.0	8.6
Burning Rate ($x10^3$g/sec)	1.6	~1.0
Density (g/cm^3)	1.35	1.18
Composition Weight ($x10^3$g)	56.7	56.7

*Silicone formula: Sylgard 182 mix.
Epoxy formula: 30% DER 732. 70% DER 321 and 11 phr DEH 24.

APPENDIX VI

DIAMETER STUDY GRAPHS

Figure 17: Luminous efficiency vs candle diameter. Shows behavior for end burning solid cylindrical pressed candles with paper candle case all burned in vertical position on MAPI site with flame pointed downward.

Figure 18: Luminous efficiency vs candle diameter. Shows behavior for end burning solid cylindrical cast candles with paper candle case all burned in vertical position on MAPI site with flame pointed downward.

Figure 19: Luminous efficiency vs candle diameter. Shows degradation of efficiency for silicone cast candles as diameter increases. Numbers on data points are the candle MAPI test numbers.

Figure 20: Luminous efficiency vs candle diameter. Shows degradation of efficiency for polysulfide cast candles as diameter increases. Numbers on data points are the candle MAPI test numbers.

Figure 21: Luminous efficiency vs candle diameter. Shows degradation of efficiency for polyester cast candles as diameter increases. Numbers on data points are the candle MAPI test numbers.

Figure 22: Luminous efficiency vs candle diameter. Shows degradation of efficiency for epoxy cast candles as diameter increases. Numbers on data points are the candle MAPI test numbers

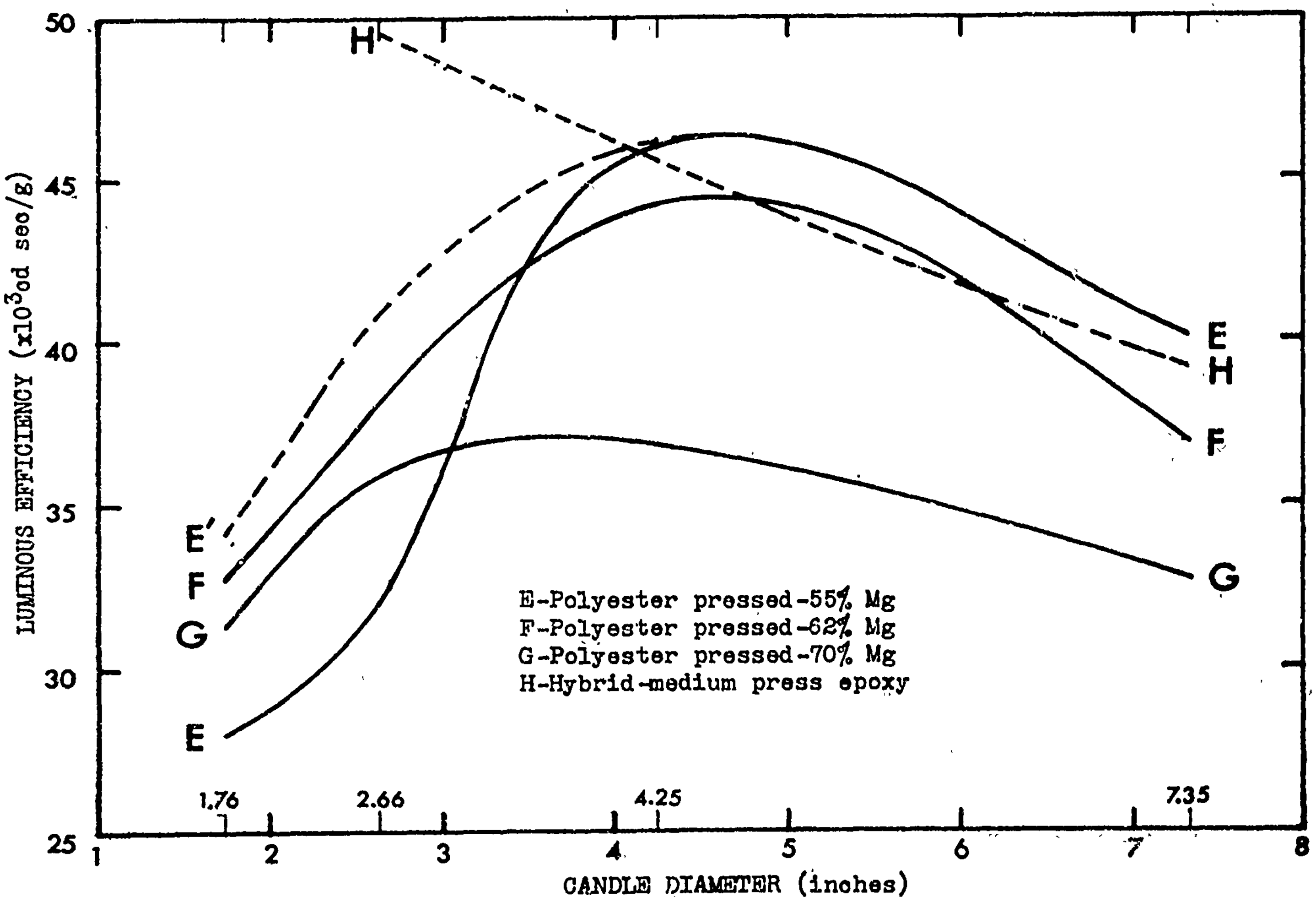


Figure 17: Luminous efficiency vs candle diameter. Shows behavior for end burning solid cylindrical pressed candles with paper candle case all burned in vertical position on MAPI site with flame pointed downward.

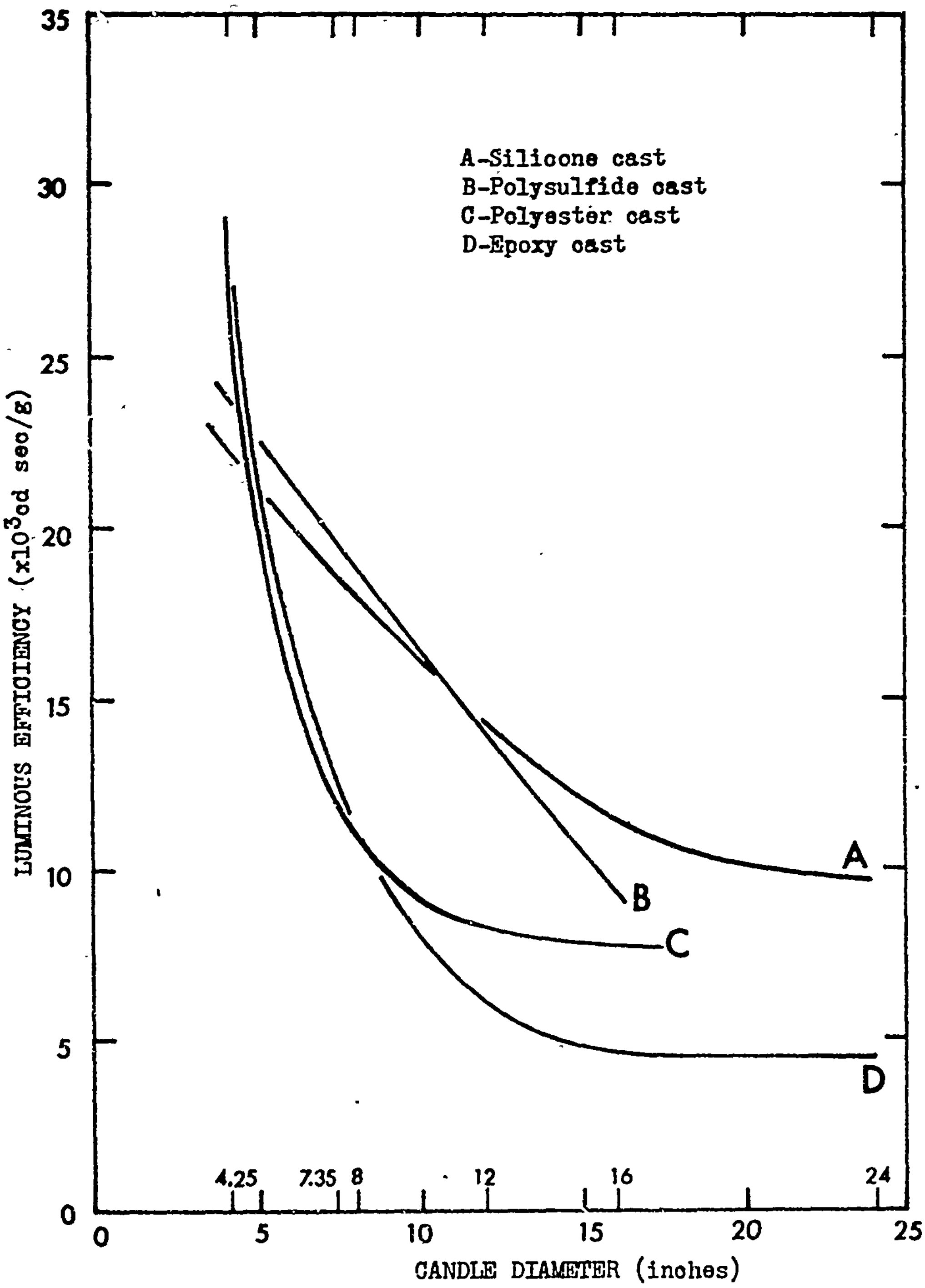


Figure 18: Luminous efficiency vs candle diameter. Shows behavior for end burning solid cylindrical cast candles with paper candle case all burned in vertical position on MAPI site with flame pointed downward.

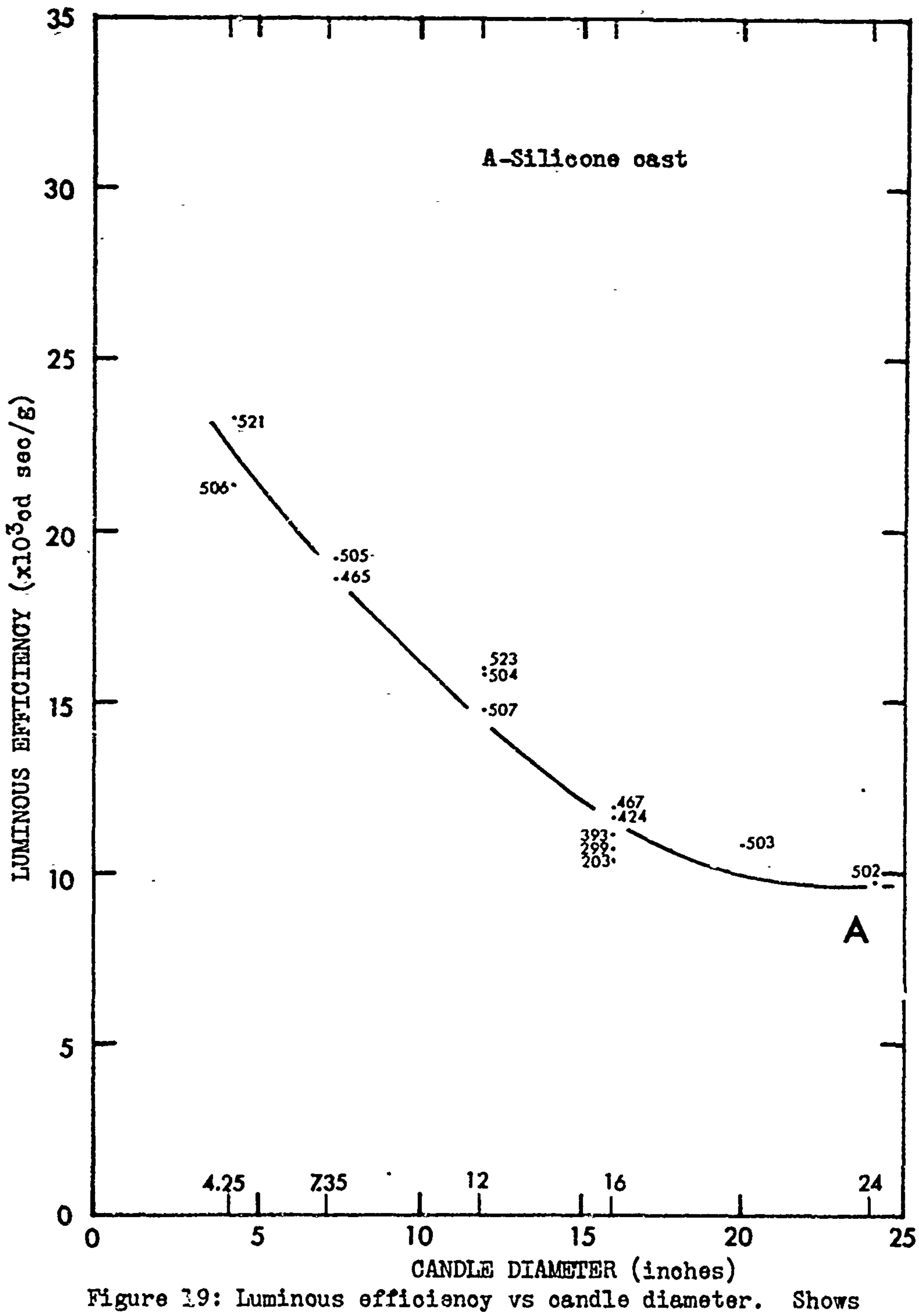


Figure 19: Luminous efficiency vs candle diameter. Shows degradation of efficiency for silicone cast candles as diameter increases. Numbers on data points are the candle MAPI test numbers.

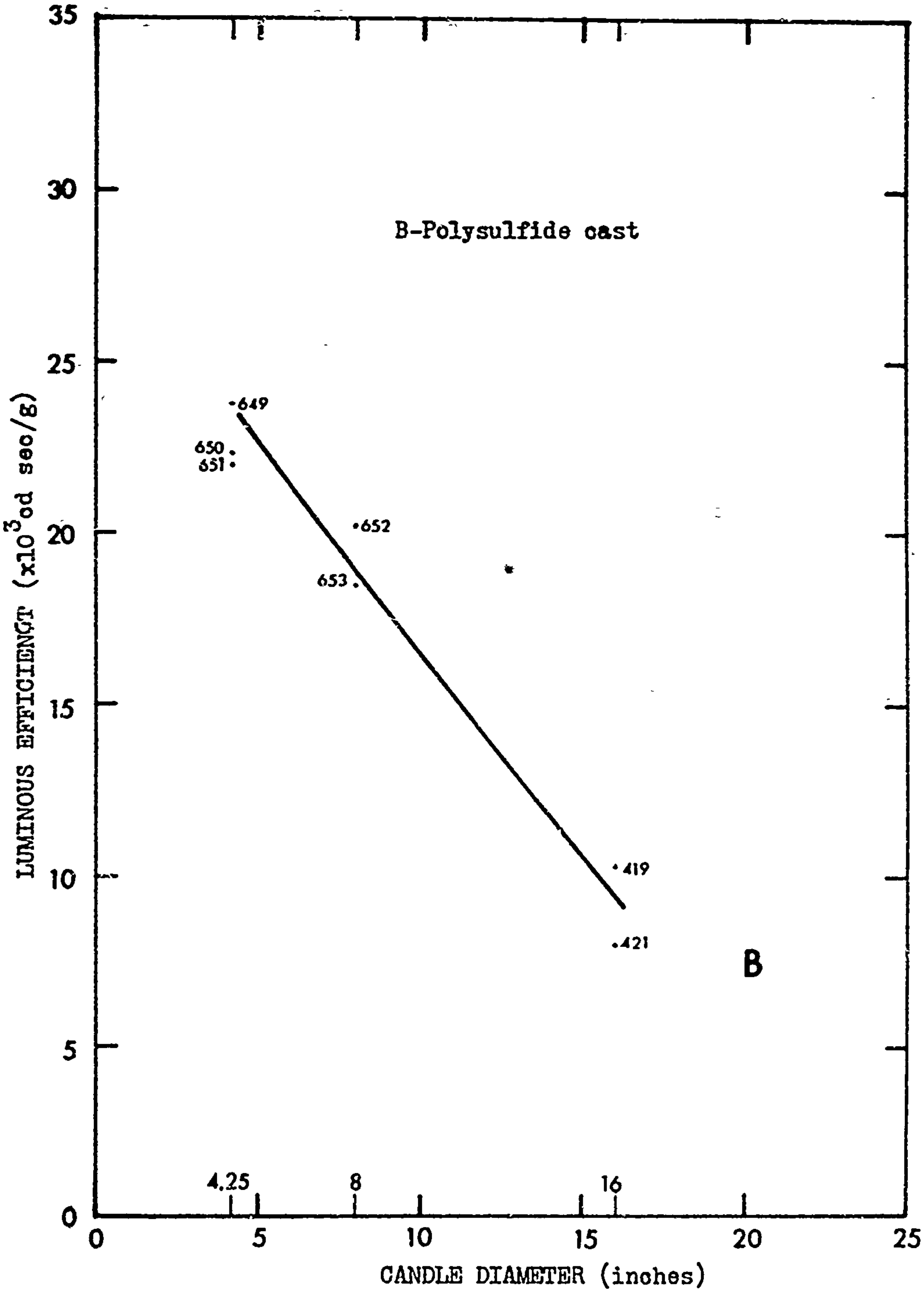


Figure 20: Luminous efficiency vs candle diameter. Shows degradation of efficiency for polysulfide cast candles as diameter increases. Numbers on data points are the candle MAPI test numbers.

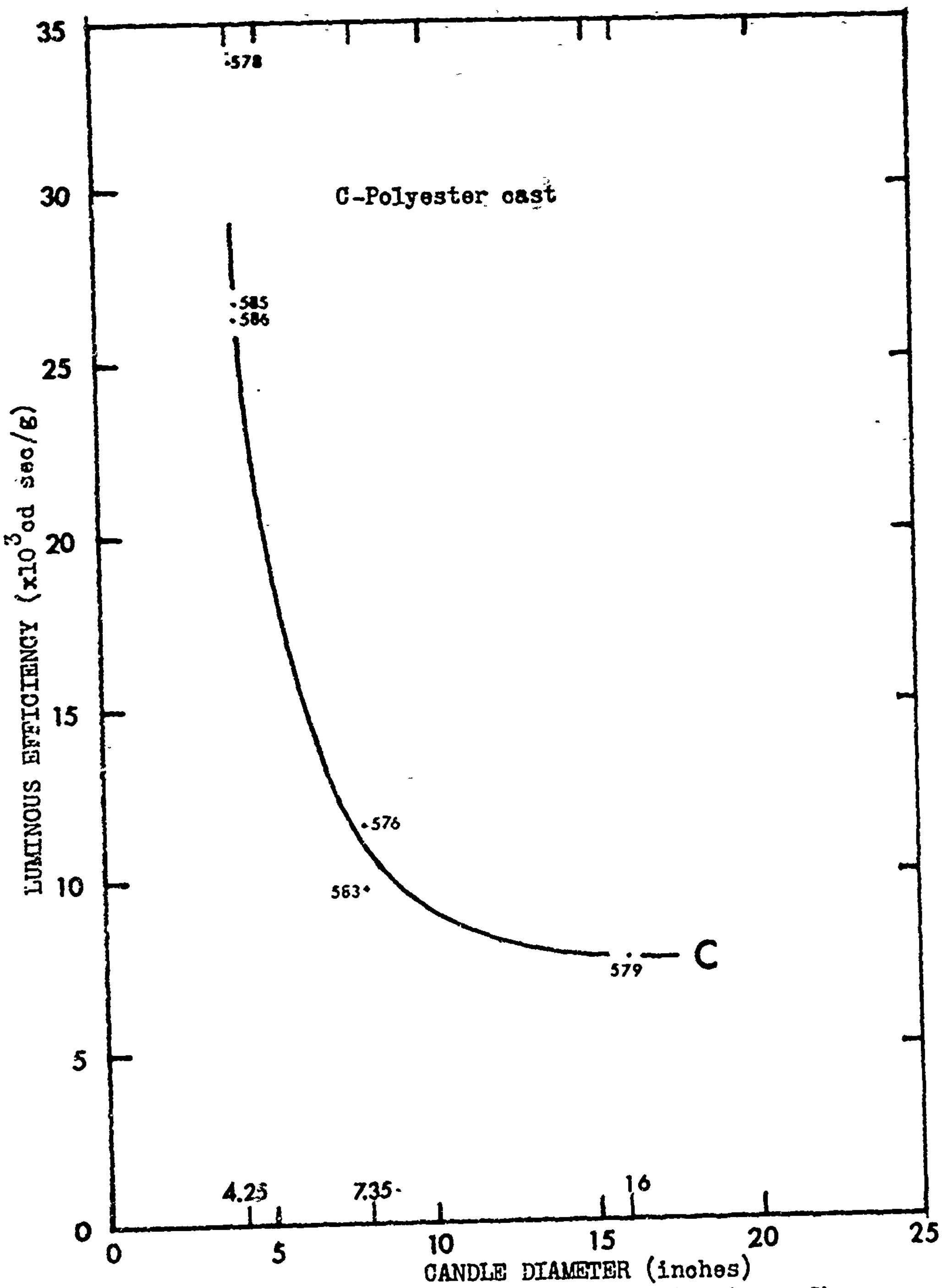


Figure 21: Luminous efficiency vs candle diameter. Shows degradation of efficiency for polyester cast candles as diameter increases. Numbers on data points are the candle MAPI test numbers.

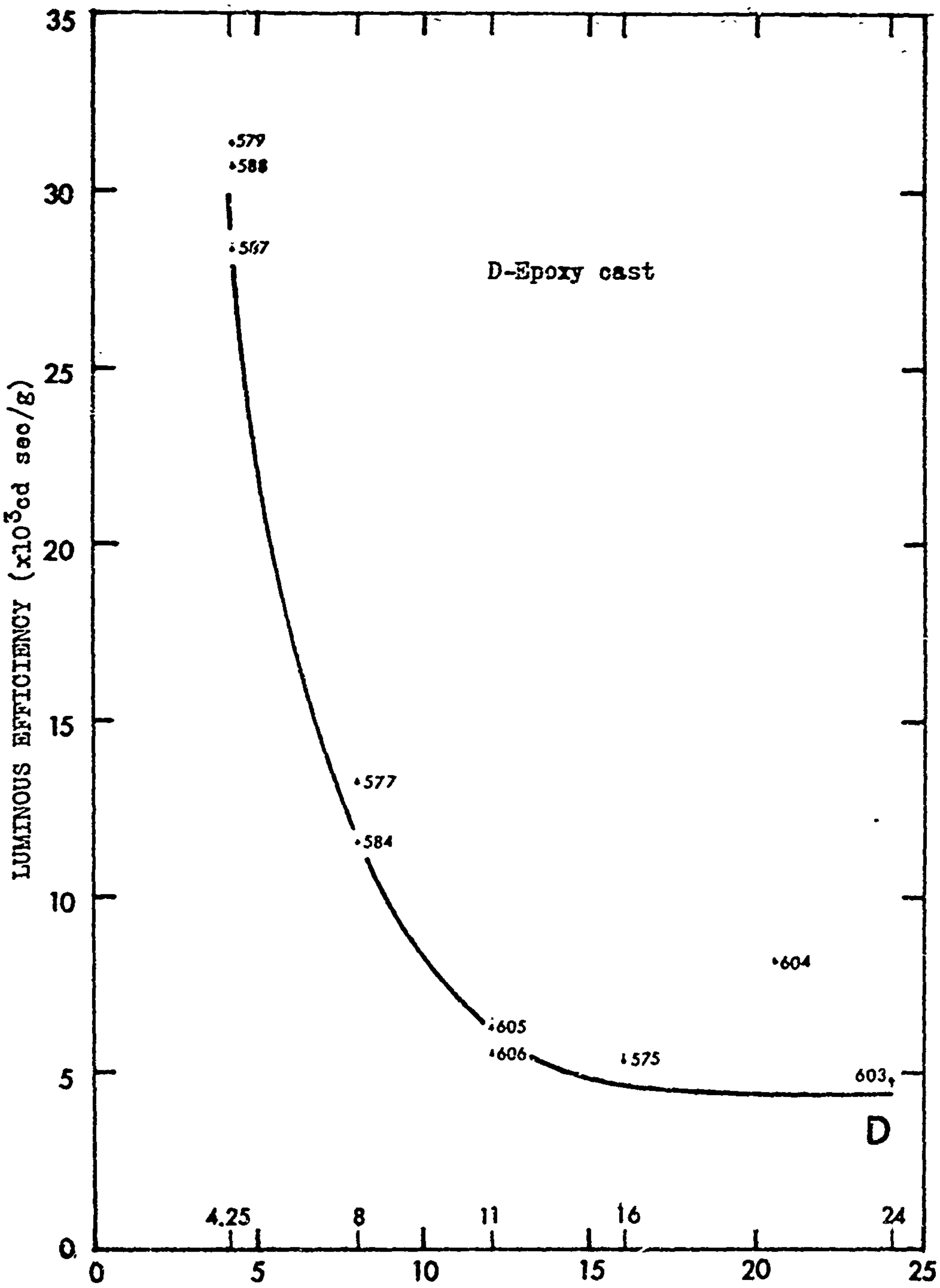


Figure 22: Luminous efficiency vs candle diameter. Shows degradation of efficiency for epoxy cast candles as diameter increases. Numbers on data points are the candle MAPI test numbers.

APPENDIX VII

EFFECTIVE BRIGHTNESS CURVES
(for pressed candles)

Figure 23: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles pressed with 5% polyester binder and 55% magnesium. Q group tested in January 67; L group in March 67. Numbers on data points are the candle MAPI test numbers.

Figure 24: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles pressed with 5% polyester binder and 62% magnesium. P group tested in January; M group in March 67. Numbers on data points are the candle MAPI test numbers.

Figure 25: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles pressed with 5% polyester binder and 70% magnesium. R group tested in January 67; N group in March 67. Numbers on data points are the candle MAPI test numbers.

Figure 26: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles pressed with silicone binders. Numbers on data points are the candle MAPI test numbers.

Figure 27: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles pressed with epoxy binder. Numbers on data points are the candle MAPI test numbers.

Figure 28: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for hybrid candles pressed with medium pressure with epoxy binder. Numbers on data points are the candle MAPI test numbers.

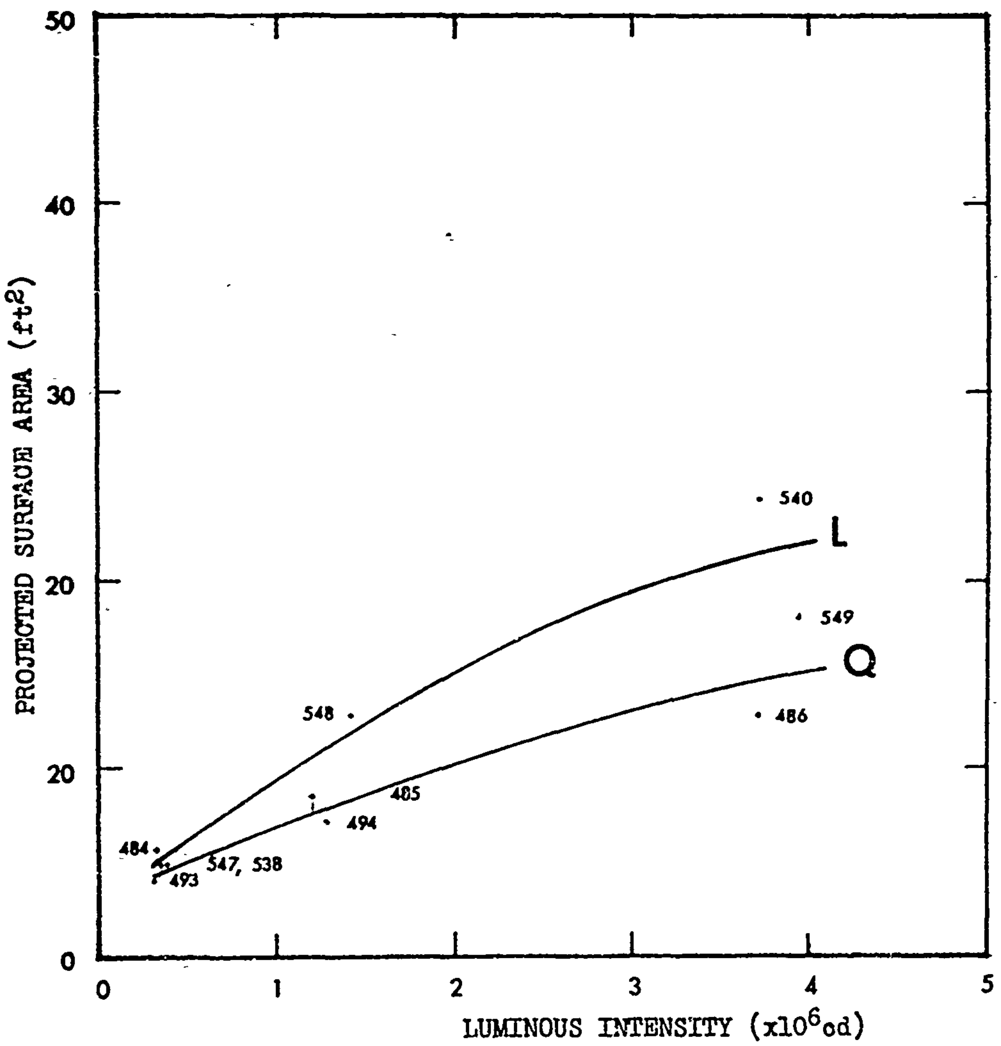


Figure 23: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles pressed with 5% polyester binder and 55% magnesium. Q group tested in January 67; L group in March 67. Numbers on data points are the candle MAPI test numbers.

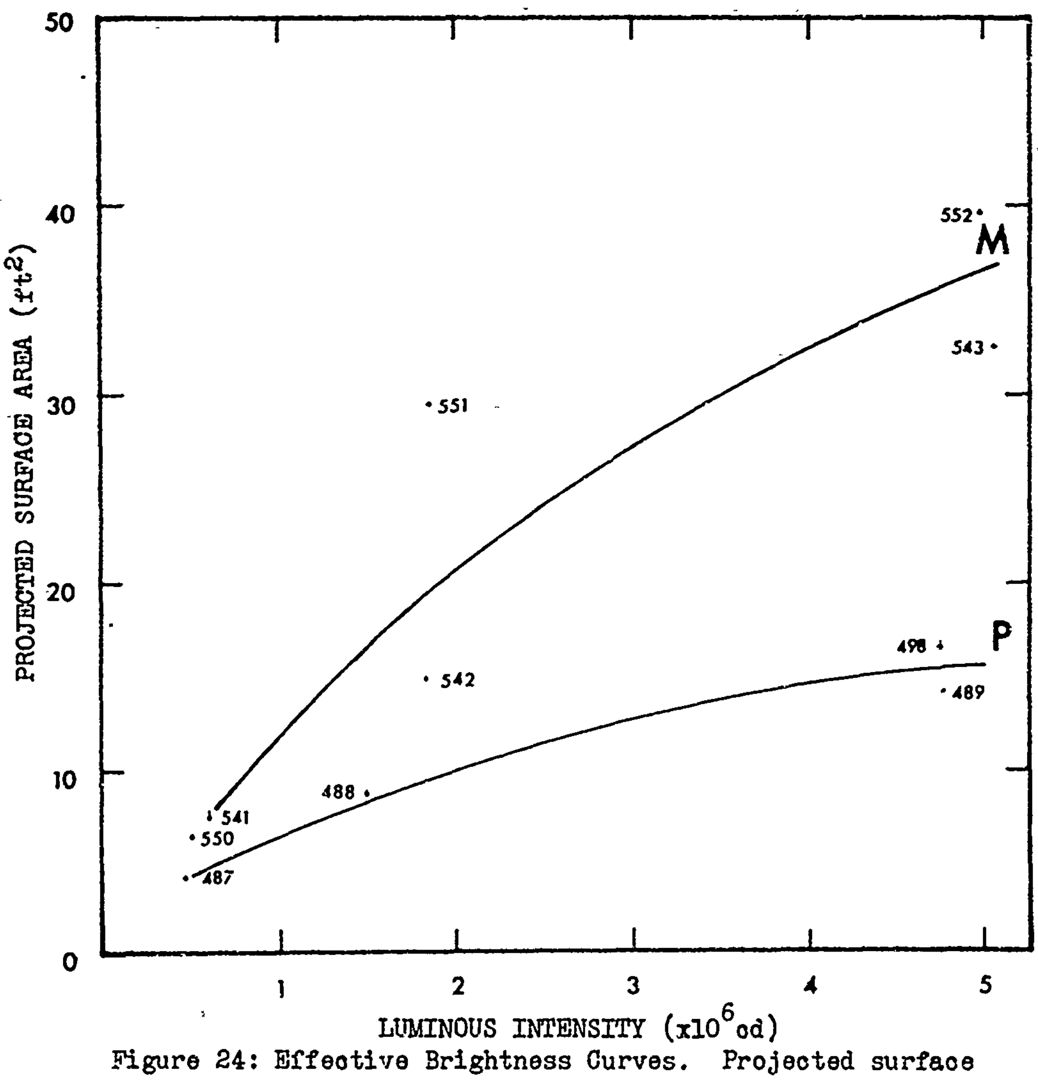


Figure 24: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles pressed with 5% polyester binder and 62% magnesium. P group tested in January; M group in March 67. Numbers on data points are the candle MAPI test numbers.

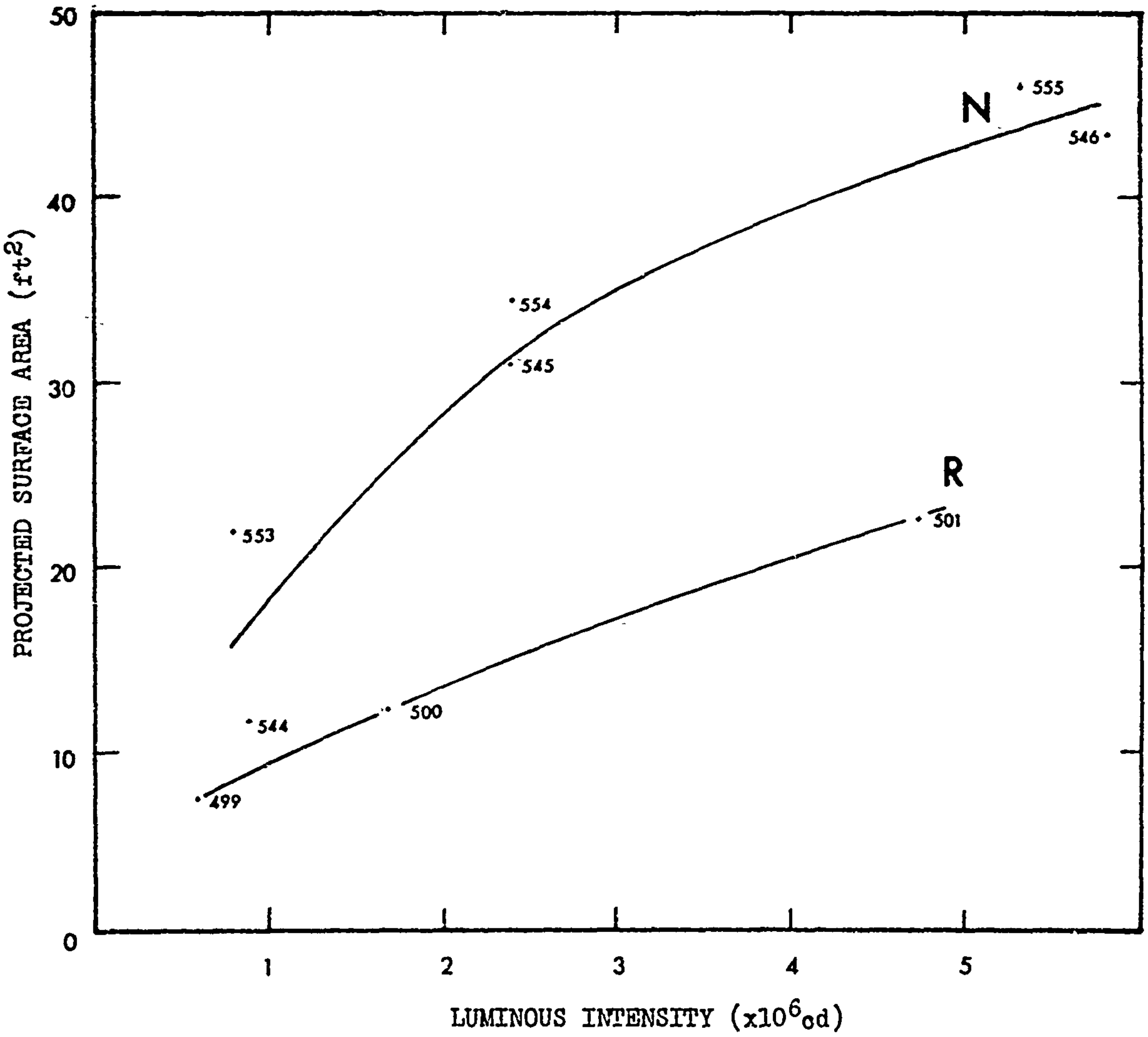


Figure 25: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles pressed with 5% polyester binder and 70% magnesium. R group tested in January 67; N group in March 67. Numbers on data points are the candle MAPI test numbers.

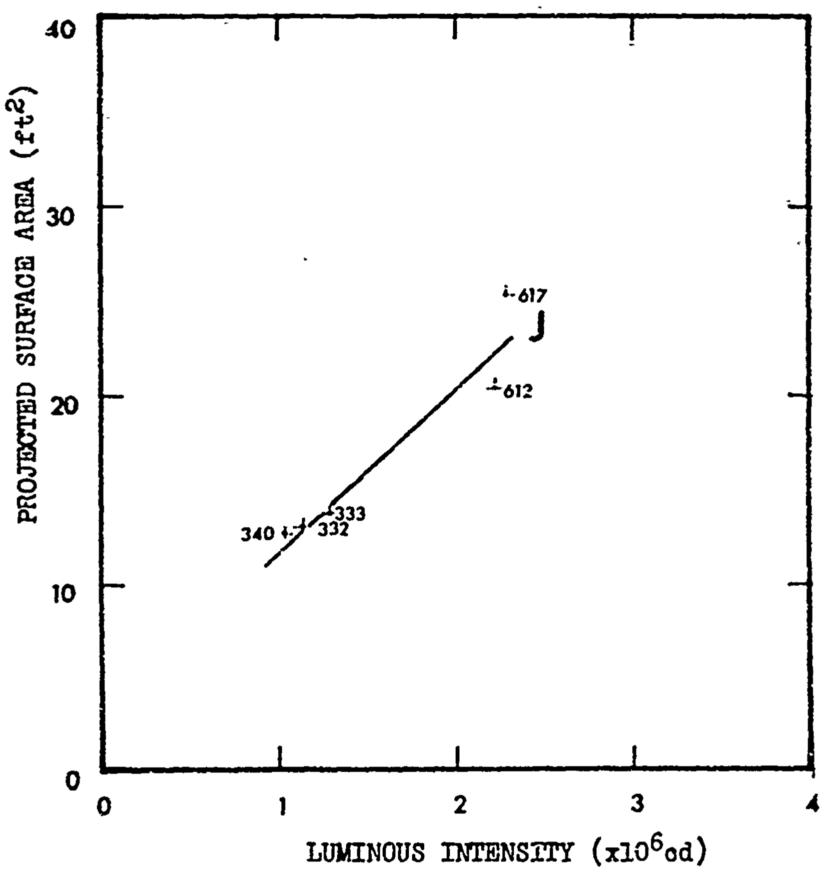


Figure 26: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles pressed with silicone binders. Numbers on data points are the candle MAPI test numbers.

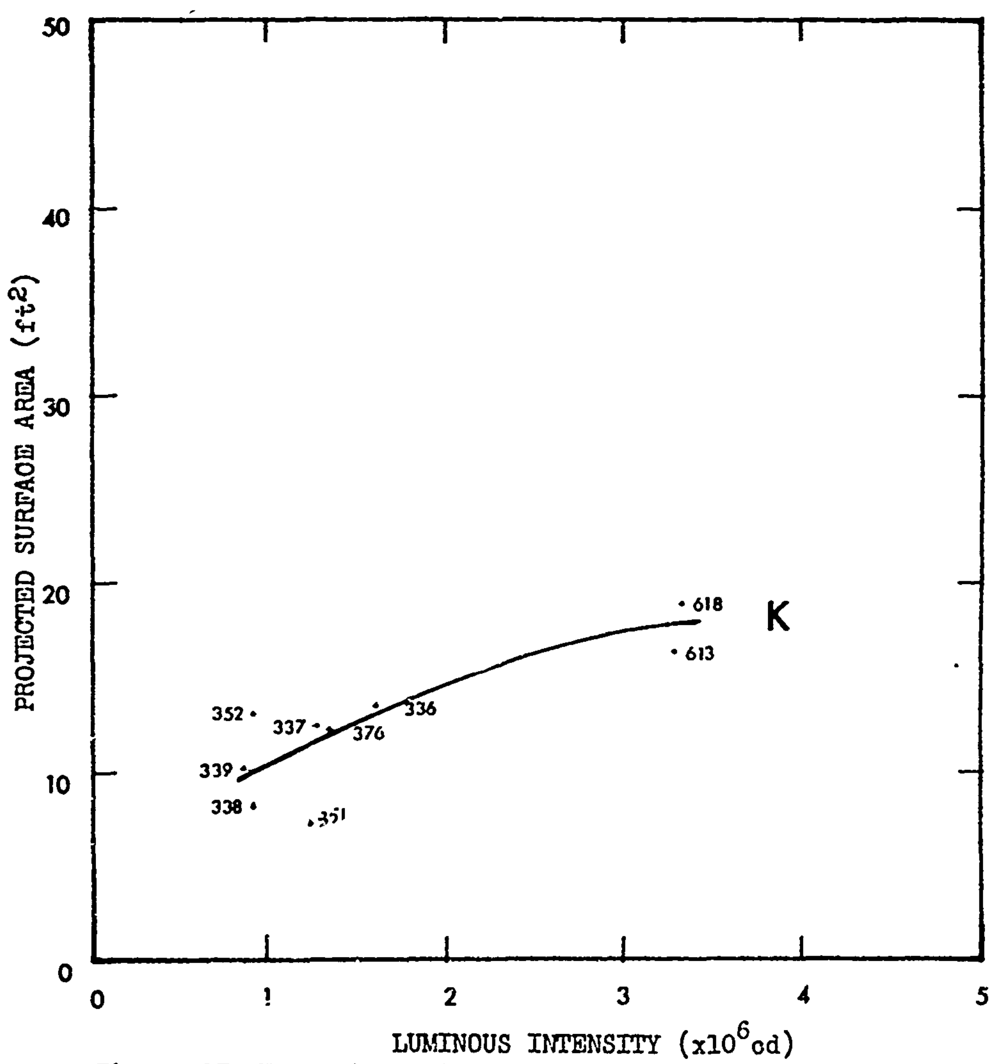


Figure 27: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles pressed with epoxy binder. Numbers on data points are the candle MAPI test numbers.

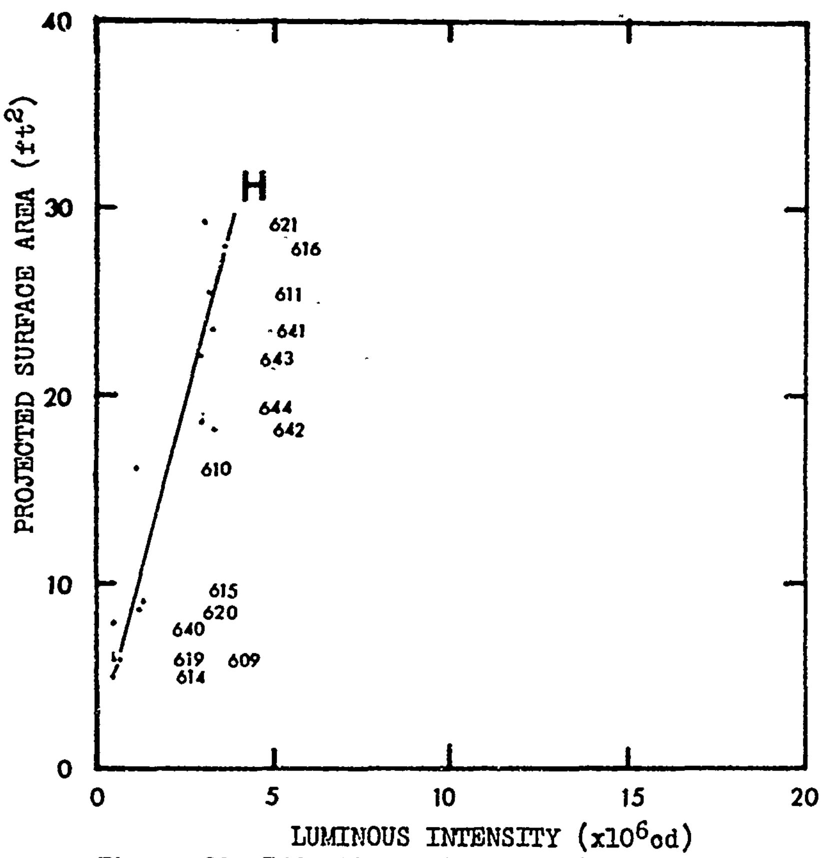


Figure 28: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for hybrid candles pressed with medium pressure with epoxy binder. Numbers on data points are the candle MAPI test numbers.

APPENDIX VIII

EFFECTIVE BRIGHTNESS CURVES
(for cast candles)

Figure 29: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles cast with silicone binder. Numbers on data points are the candle MAPI test numbers.

Figure 30: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles cast with epoxy binder. Numbers on data points are the candle MAPI test numbers.

Figure 31: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles cast with polyester binder. Numbers on data points are the candle MAPI test numbers.

Figure 32: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles cast with polysulfide binder. Numbers on data points are the candle MAPI test numbers.

Figure 33: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles cast in an aluminum candle case with a polyester-epoxy binder. Numbers on data points are the candle MAPI test numbers.

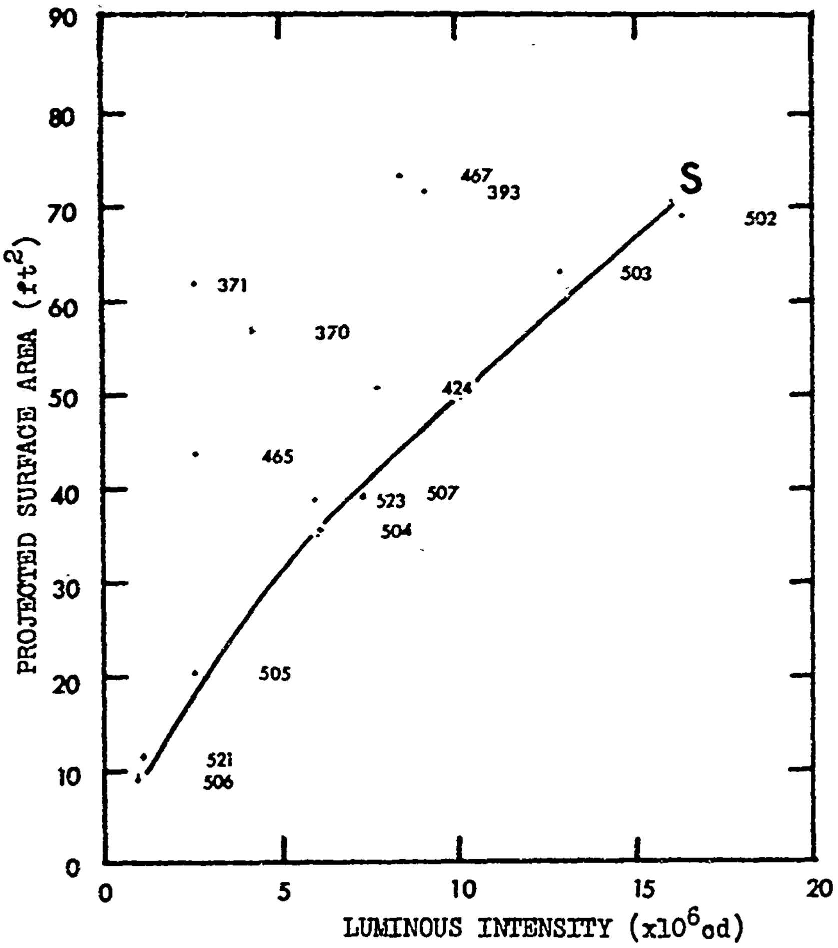


Figure 29: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles cast with silicone binder. Numbers on data points are the candle MAPI test numbers.

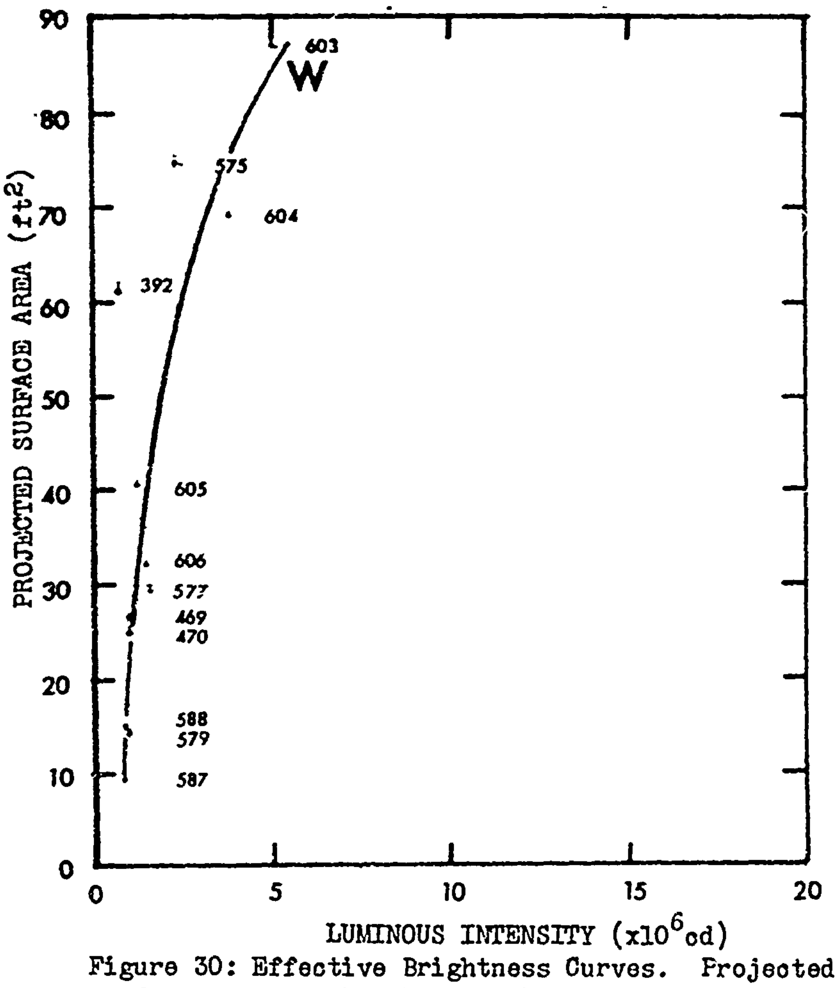


Figure 30: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles cast with epoxy binder. Numbers on data points are the candle MAPI test numbers.

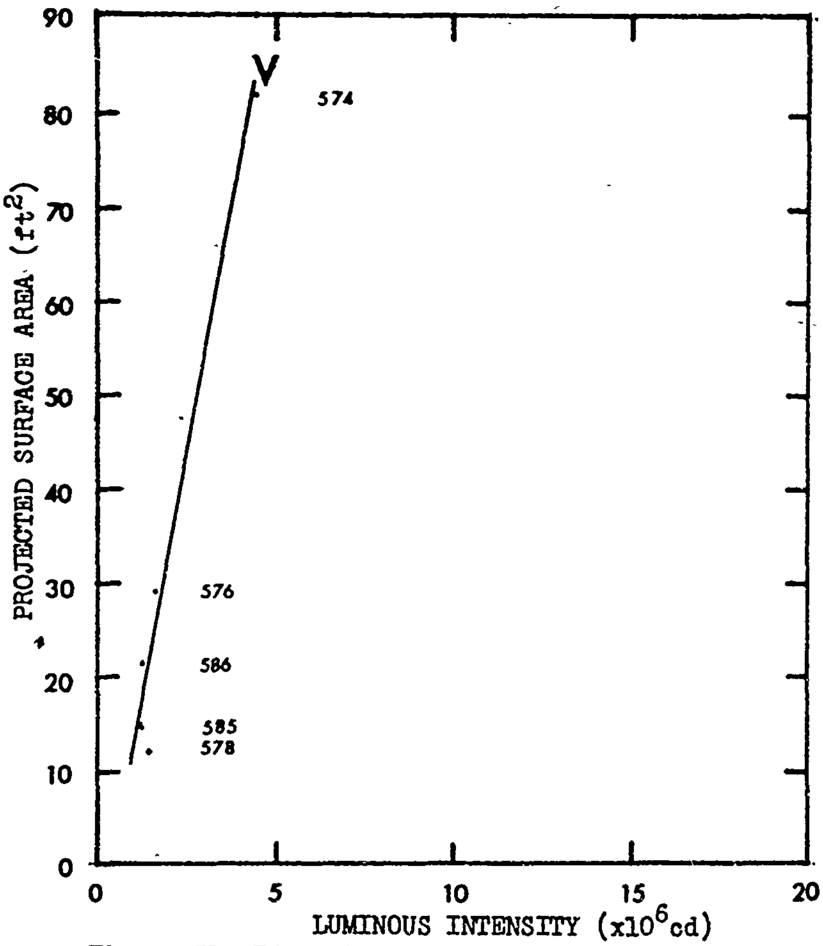


Figure 31: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles cast with polyester binder. Numbers on data points are the candle MAPI test numbers.

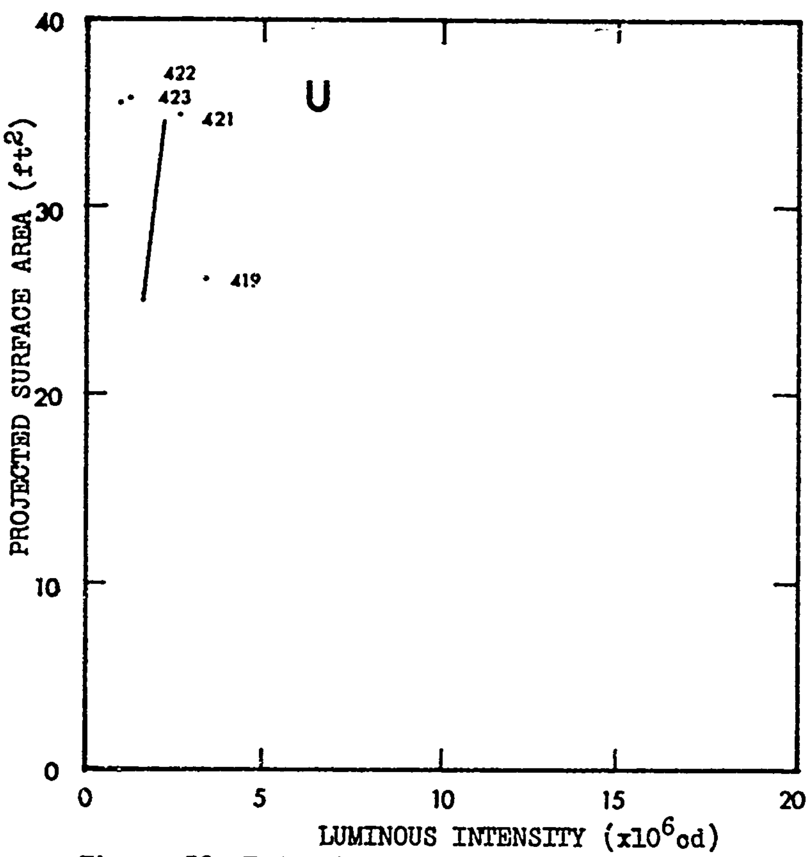


Figure 32: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles cast with polysulfide binder. Numbers on data points are the candle MAPI test numbers.

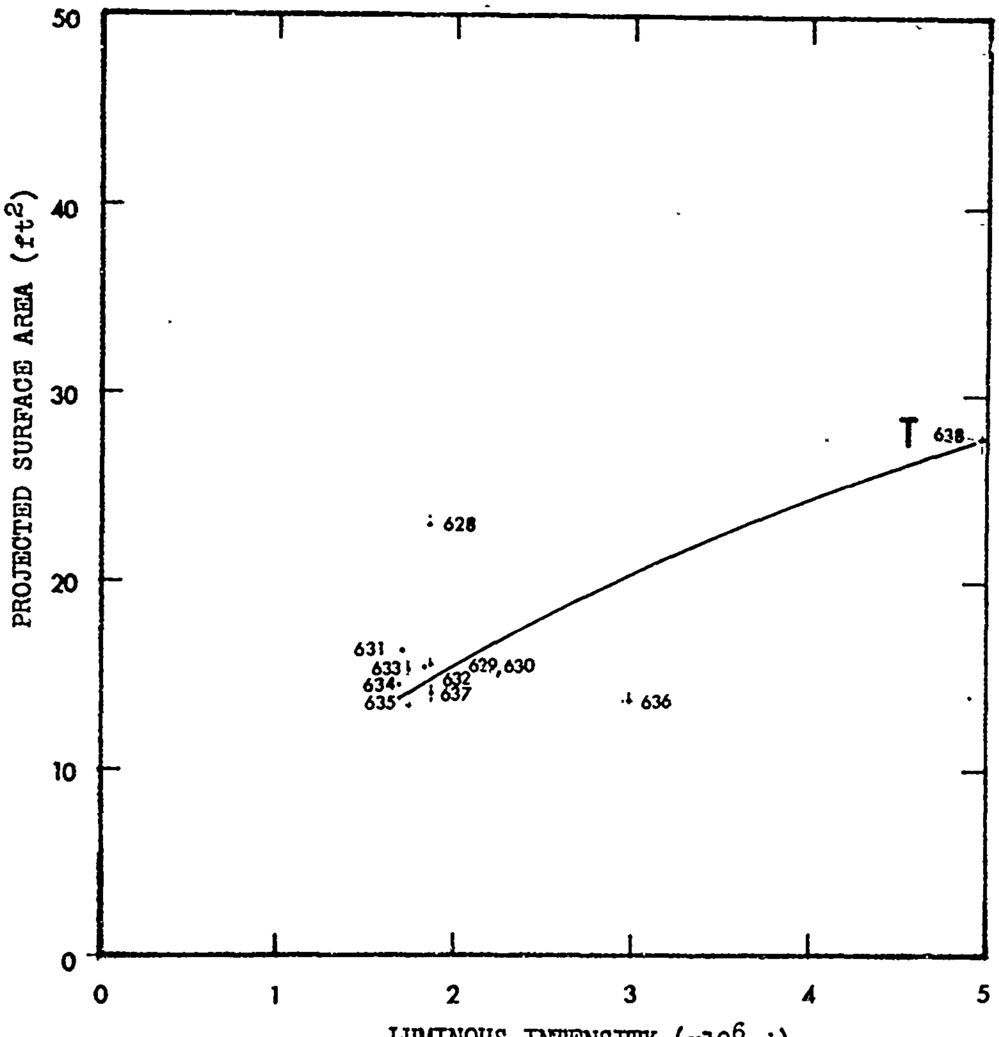


Figure 33: Effective Brightness Curves. Projected surface area of the flame vs luminous intensity for candles cast in an aluminum candle case with a polyester-epoxy binder. Numbers on data points are the candle M&PI test numbers.

APPENDIX IX

Polar Plots of Light Distribution for Candles 426 and 394

Figure 15: Luminous intensity ($x10^6$cd) by photocell at about the 12th second into the burn of double star cavity candle MAPI 426.

Figure 34: Luminous intensity ($x10^6$cd) by photocell at about the 20th second into the burn of double star cavity candle MAPI 426.

Figure 35: Luminous intensity ($x10^6$cd) by photocell at about the 10th second into the burn of double star cavity candle MAPI 394.

Figure 36: Luminous intensity ($x10^6$cd) by photocell at about 20th second into the burn of double star cavity candle MAPI 394.

Figure 37: Luminous intensity ($x10^6$cd) by photocell at about 30th second into the burn of double star cavity candle MAPI 394.

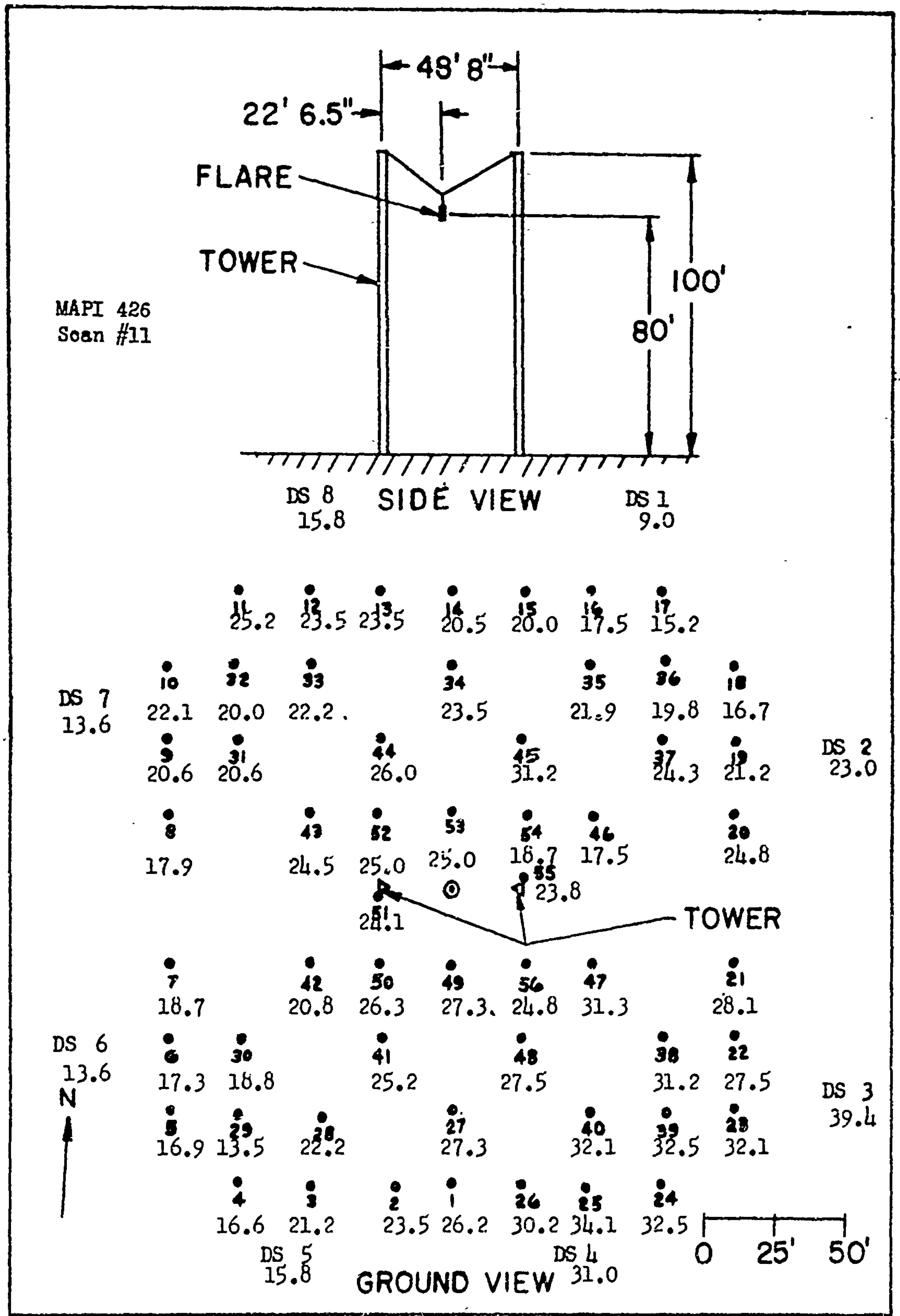


Figure 15: Luminous intensity (x10^6cd) by photocell at about the 12th second into the burn of double star cavity candle MAPI 426.

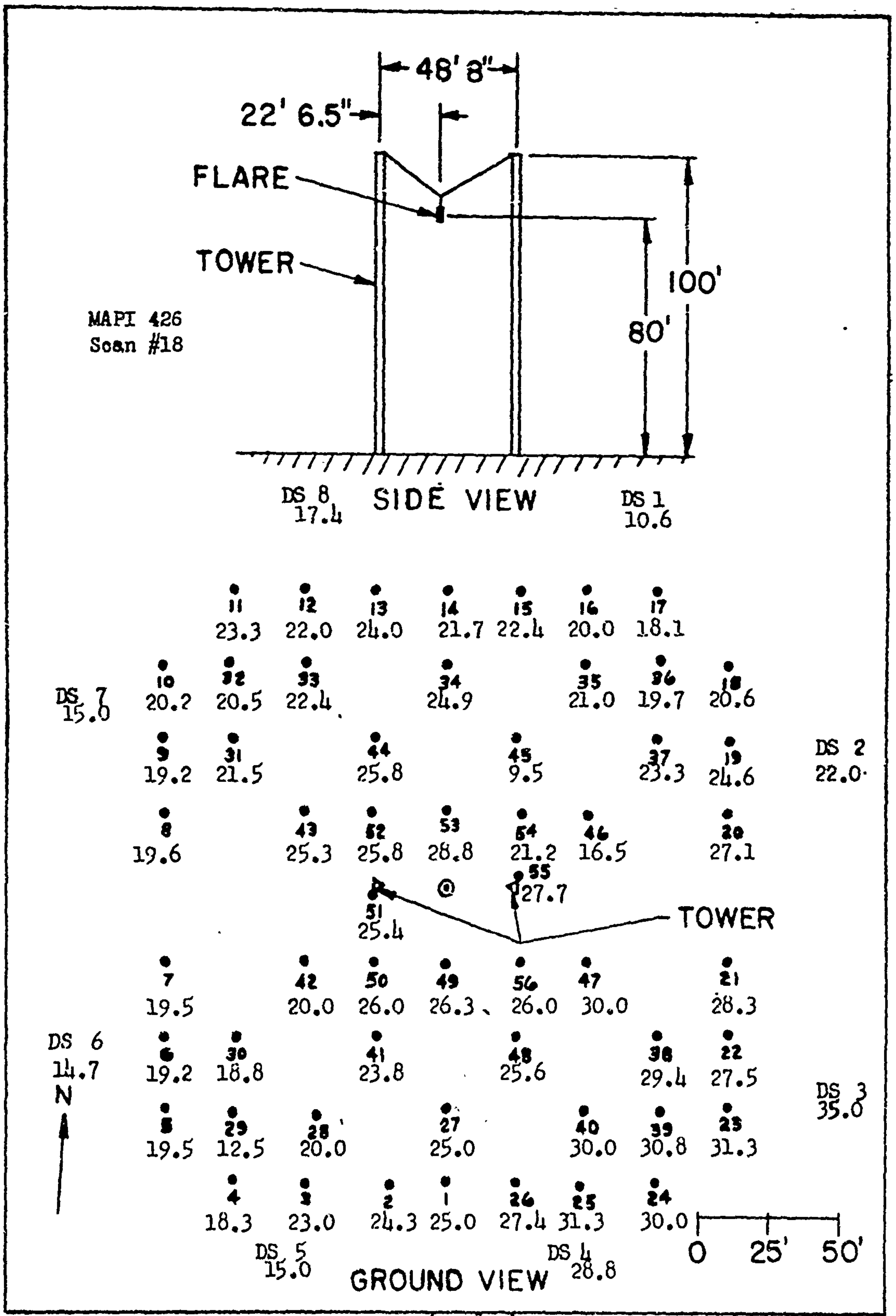


Figure 34: Luminous intensity ($x10^6$cd) by photocell at about the 20th second into the burn of double star cavity candle MAPI 426.

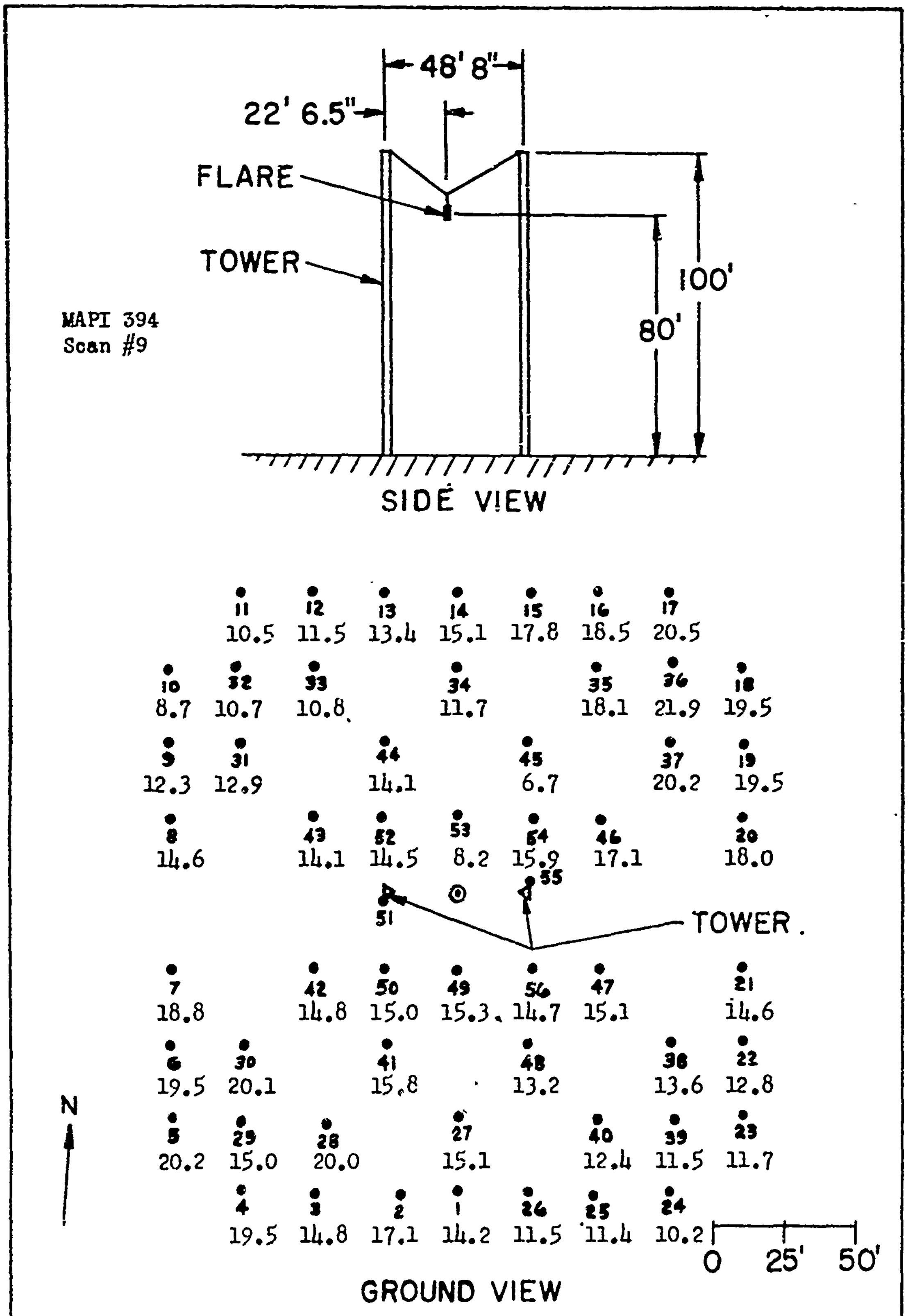


Figure 35: Luminous intensity ($x10^6$cd) by photocell at about the 10th second into the burn of double star cavity candle MAPI 394.

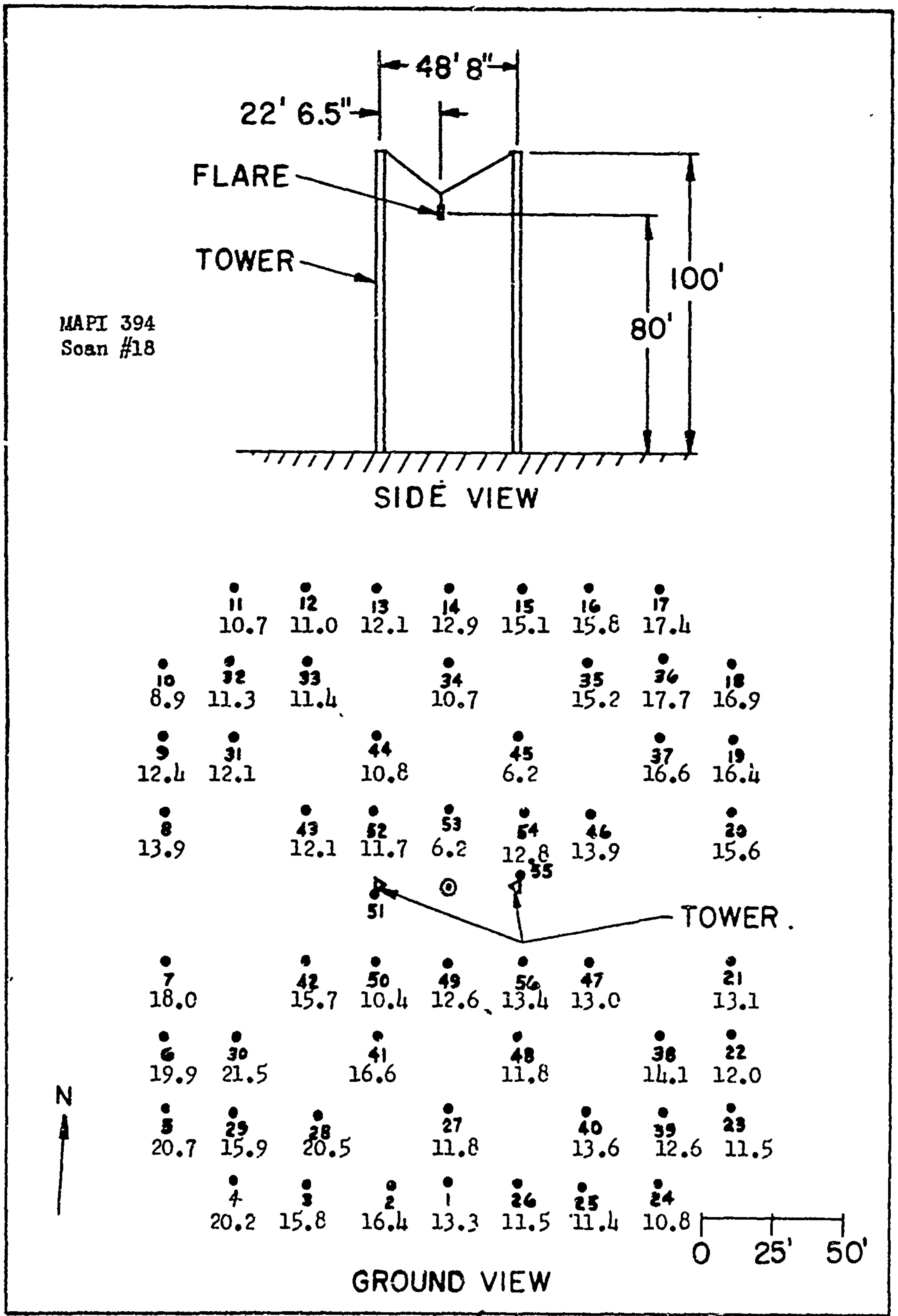


Figure 36: Luminous intensity ($x10^6$cd) by photocell at about 20th second into the burn of double star cavity candle MAPI 394.

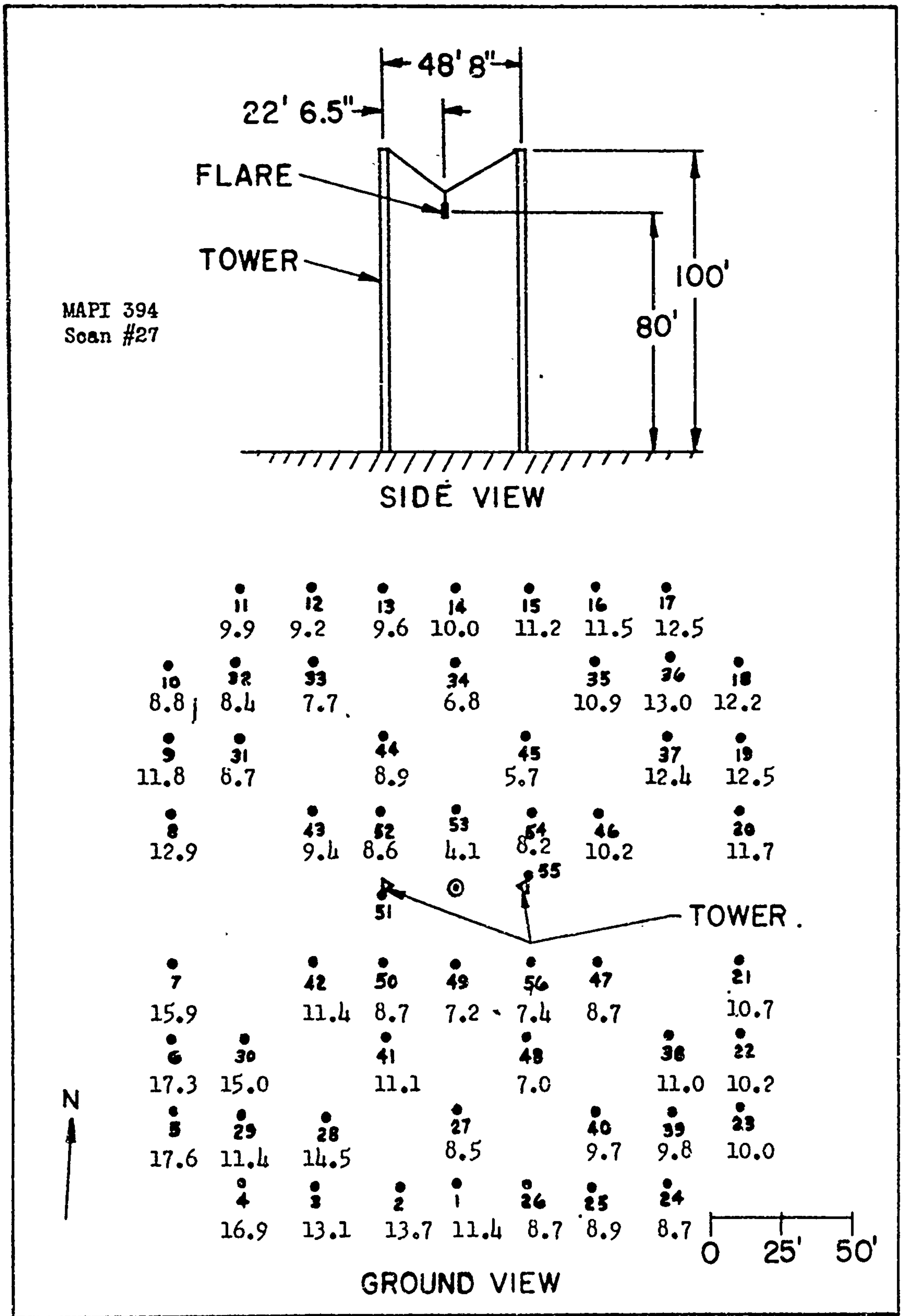


Figure 37: Luminous intensity ($x10^6$cd) by photocell at about 30th second into the burn of double star cavity candle MAPI 394.

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Naval Ammunition Depot Crane, Indiana 47522	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

25 MILLION CANDLE CAST FLARE
DIAMETER AND BINDER STUDY VOLUME II

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Summary Report June 66 to June 67

5. AUTHOR(S) (Last name, first name, initial)

DOUDA, Bernard E.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
January 1968		9

8a. CONTRACT OR GRANT NO. MIPR PG-6-58	9a. ORIGINATOR'S REPORT NUMBER(S) RDTR No. 105 VOLUME II
b. PROJECT NO.	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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13. ABSTRACT The feasibility of making an illuminating candle which produces a luminous intensity of 25 million candles is demonstrated. The goal is achieved by igniting all surfaces of a star shaped cavity which is formed through the center of the candle.

The relationship between candle diameter and the ability of that candle to generate light efficiently is reported. A general degradation of efficiency is observed as the cast candle diameter increases from 4 inches to 24 inches.

Silicone, epoxy-polyglycol, polyester, polysulfide, epoxy-polyester, sodium perchlorate-methyl methacrylate, and various combinations of these binders are described as they are used to make candles for the diameter study, the binder study, and the 25 million candle flare.

Flame orientation and flame size effects are described. Contrary to common opinion, it is shown that a small flame size rather than a large flame from a given candle diameter is associated with candles which produce light with high efficiency. The binder is shown to be a major factor in the generation of various flame sizes and thus strongly influences the candle efficiency.

DD FORM 1 JAN 64 1473 0101-807-6800

Security Classification

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14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Flares						
Illuminating Compositions						
Cast Flares						
Binder Study						
Epoxy Resins						
Methacrylates						
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Sodium Nitrate						
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